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EARTH SCIENCES

No. 25

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INVESTIGATING PARAMETERS OF SEA SUBMICRON AEROSOLS AND THEIR ROLE IN ATMOSPHERIC PROCESSES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 26 May 81, after revision 21 Oct 81) pp 933-943

ZHULANOV, Yu. V., NEVSKIY, I. A. and PETRYANOV, I. V., Physicochemical Scientific Research Institute imeni L. Ya. Karpov

[Abstract] A study was made of the spectrum of sizes and spatial-temporal inhomogeneity of the field of concentrations of marine aerosols, the mechanism of formation of marine salt particles, the spectrum of their sizes and its transformation in the atmosphere. The role of salt particles as cloud condensation nuclei is considered. Investigations of the spectrum of sizes of particles were made with a laser aerosol spectrometer. This made it possible to register particles in the following size ranges: 0.05-0.10, 0.10-0.15, 0.15-0.25, 0.25-0.35, 0.35-0.50, 0.50-0.75, 0.75-1.0, > 1.0 μm in radius. The response of the instruments used ensures direct measurements of the concentration and dispersion of marine salt particles capable of acting as cloud condensation nuclei with typical supersaturations in clouds < 0.4%. The described investigations of the aerosol component were made on the 16th voyage of the "Ernst Krenkel'" in the Atlantic Ocean, Black, Mediterranean and Baltic Seas. Most measurements were made hourly. All the collected data confirm the importance of marine salt particles in atmospheric processes, cloud formation and the scattering of solar radiation. These studies of the field of concentrations of marine aerosols in different regions revealed its considerable horizontal inhomogeneity and relationship to meteorological parameters. The concentrations of marine aerosols for the most part are in the range 10^2-10^3 cm^{-3}. The maximum in the distribution of marine aerosols by sizes falls on particles with a radius 0.05-0.10 μm. A study of the mechanism of the formation of marine aerosols indicates a generation of particles primarily with a radius of 0.05-0.15 μm. Most of the sulfate submicron particles detectable over the ocean are probably formed during the oxidation of SO_2 in primary marine salt particles. This process accounts to a high degree for the disappearance of SO_2 in the atmosphere. The shift in the distribution maximum in transforming marine aerosols under conditions of low concentrations over the ocean is governed to a lesser degree by coagulation and to a greater degree by an increase in the mass of particles due to the oxidation of atmospheric SO_2 in them. Figures 5; references 28: 9 Russian, 19 Western. [7-5303]

UDC 551.596.1:551.501.75:551.501.724

ACOUSTIC RETURN-SLANT ATMOSPHERIC SOUNDING

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 18, No 9, Sep 82 (manuscript received 19 Jan 82) pp 899-904

OSTASHEV, V. Ye., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] There are now many experimental methods for determining the vertical profiles of temperature T and wind velocity v in the lower troposphere, but each of them has significant shortcomings. The author accordingly proposes a new method for reconstructing the vertical structure of meteorological elements in the lower part of the troposphere, explained as follows. The trajectory of propagation of an acoustic wave in the atmosphere is dependent on the T and v profiles. In particular, when there is a temperature inversion there can be cases when the acoustic wave radiated by a surface source at a small angle to the earth's surface, as a result of refractional curvature of the trajectory, is incident on the earth's surface. The acoustic wave will usually experience scattering on the earth's surface; some of the scattered waves, as a result of refraction, may enter the radiation detector. With such a formulation of the problem the measured parameter is the time between the radiated and received signals. By knowing the dependence $\tau = \tau(\theta, \varphi)$, where φ is the azimuth angle of the radiated signal, it is possible to reconstruct the temperature and wind velocity profiles. Such a scheme is very similar to return-slant sounding of the ionosphere, and therefore it is proposed that this method be called return-slant acoustic sounding of the atmosphere. The article gives solutions of the direct problem of refraction of acoustic waves in a stratified atmosphere and the inverse problem of reconstructing temperature and wind velocity on the basis of the time between the radiated and received signals. Various considerations are given on the practical feasibility of return-slant acoustic sounding. References 5: 3 Russian, 2 Western.
[7-5303]

AZERBAIJAN SCIENTISTS WORK ON SECOND VOYAGE OF 'VITYAZ''

Baku VYSHKA in Russian 29 Dec 82 p 4

[Article by Ad. Aliyev, laboratory director, Geology Institute, Azerbaijan Academy of Sciences]

[Text] During recent decades there has been great emphasis on the problem of study of the oceans and seas and exploitation of their riches. Means which are commensurable with the expenditures on space exploration are being invested by many countries of the world in investigation of the world ocean, occupying 70% of the earth's entire surface. Serious attention is also being devoted to this problem by Soviet scientists -- geologists, geophysicists, geochemists, biologists and others. Indeed, the floor of the oceans and seas constitutes an almost untouched storehouse of mineral wealth.

Already for some time scientific specialists of the Geology Institute, Azerbaijan Academy of Sciences, have been participating in sea expeditions for study of the world ocean. For example, they have traversed the expanses of the Pacific, Indian and Atlantic Oceans as participants in multisided expeditions of the USSR Academy of Sciences aboard the scientific research ships "Vityaz'," "Persey," "Akademik Vernadskiy."

This year scientists of our institute have been participants on the second voyage of the scientific research ship "Vityaz'." These include the director of the Microfauna and Mesozoic Stratigraphy Laboratory, Khalil Aliyulla, doctor of geological sciences, and a senior scientific specialist in the Regional Geology Laboratory, Rustam Babayev, candidate of geological and mineralogical sciences. Over a period of three months they carried out geological investigations in the central part of the Atlantic Ocean.

The "Vityaz'" is a new scientific research ship constructed in Poland. It is outfitted with modern navigational instruments, scientific equipment, electronic computers, housed in 26 ship laboratories. A special feature of the "Vityaz'," in contrast to its predecessors, is the presence of an underwater vehicle, with self-contained controls, the "Argus," and an underwater complex for carrying out diving work using the "Kolokol" pressure chamber.

The principal organizers and implementers of the expeditionary work were the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Physics Institute, USSR Academy of Sciences, and Geological Institute, Azerbaijan Academy of Sciences. Participating in this specialized hydrological-biological expedition were scientists from Moscow, Leningrad, Baku, Vil'nyus and Gelendzhik, as well as geologists and botanists from East Germany and Czechoslovakia. The expedition was headed by the well-known Soviet professional oceanologist A. Aksenov, doctor of geographical sciences, a major investigator of the seas and oceans.

In accordance with the research program, the expedition participants carried out a broad complex of hydrological, biological, geological, physical and other investigations of submarine ridges, basins and trenches in the central part of the Atlantic Ocean. The investigations were made in five polygons. These included the Josephine and Great Meteor Seamounts, North American Basin, Blake submarine plateau and Cayman Trench.

During recent years serious attention has been devoted to investigations of submarine ridges. Oceanic rises are promising regions for fishing. From the geologist's point of view these sectors of the ocean are of great scientific and practical interest for study of paleovolcanoes, that is, underwater volcanic activity in the geological past. It is most common to encounter mineral deposits precisely in such regions of the oceanic and sea floor. With respect to the paleontologists, which include our Azerbaijan specialists of the expedition, they are studying not only the geological age of the volcanic formations, but also the sequence of layers and fauna of the ancient times of the Atlantic.

During the time of the expeditionary work Azerbaijan scientists carried out a great volume of paleontological and stratigraphic investigations. Work over the ship's side was carried out at 12 stations (observation points).

It must be stated that Rustam Babayev has twice sailed in the Pacific and Indian Oceans. In 1974 he participated in the first tropical coral expedition on the scientific research ship of the Far Eastern Scientific Center of the USSR Academy of Sciences and in 1979 he was a member of a specialized geological-geophysical expedition aboard the ship "Akademik Vernadskiy." The object of his investigations was corals and coral reefs. This time he was concerned with investigation of abyssal corals of the Atlantic Ocean.

Khalil Aliyulla, doctor of geological and mineralogical sciences, for the first time is participating in underwater multisided oceanic expeditions. Over the course of many years he has been studying fossil microorganisms (foraminifers, radiolarians, concholiths, etc.) of ancient geological epochs of Azerbaijan and different regions of the Caucasus. The microorganisms which he investigated have a distinctly marine and oceanic origin in the tropical and subtropical climatic zone. That is why for his further scientific investigations it was necessary for him to obtain similar material from the warm equatorial latitudes of the Atlantic. The paleontological finds collected during the time of the second voyage of the scientific research ship "Vityaz'" unquestionably will enrich the scientific collection of this scientist with the new "modern" representatives of microorganisms. An analysis of this material will make possible a scientific clarification of some general problems in paleontology, a systematization of microfossils, paleoecology, stratigraphy and other aspects of the geology of the Caucasus.

A study of modern abyssal corals gives basis for assuming that their ancestors, living hundreds of millions of years ago in the open seas over the modern area of the Lesser Caucasus, also were abyssal species and the depths of these seas corresponded to bathymetric depths (from 200 to 1000 m) of modern seas. The results confirm the opinion of scientists that Azerbaijan at remote geological times -- millions of years ago -- was a tropical zone. They will assist in study of the problem of reef formation and also will clarify the pattern of movement of the earth's crust over our territory. In addition, operating with these data it is also possible to solve the problem of determining the stratigraphic age of geological formations. And this is very important in carrying out geological survey and exploration work for minerals.

5303
CSO: 1865/81

PAST AND PRESENT OF NORTHERN SEA ROUTE

Moscow MORSKOY FLOT in Russian No 12, Dec 82 pp 22-27, 29

[Article by K. Chubakov, head, Northern Sea Route Administration, Ministry of the Maritime Fleet, A. Arikaynen, laboratory director, All-Union Scientific Research Institute of Systemic Research, State Committee on Science and Technology and USSR Academy of Sciences, and M. Shevelev, HSU]

[Text] The USSR Council of People's Commissars on 17 December 1932 adopted a decree on the organization of the Main Administration of the Northern Sea Route (Glavsevmorput') and established the task of "finally laying out a Northern Sea Route from the White Sea to Bering Strait, the outfitting of this route, maintaining it in proper order and ensuring navigation along this route."

This governmental decree for our country was in essence the first milepost on the path to the planned and multisided exploitation of the Northern Sea Route -- the most important sea communication line of the USSR in the Arctic.

***

Our government, from the first days of Soviet rule, has devoted very close attention to study of the Arctic Ocean and the development of navigation in the Arctic. This was dictated by the need for bringing the earlier backward peoples of the Far North into the political, economic and cultural life of the Soviet state. The development of industry in the Asiatic North became economically important. The acute problem immediately arose of the organization of transportation lines between the western and eastern regions of our far-flung country.

By the beginning of the 1930's some experience had been accumulated in study of the nature of the Arctic and exploitation of its seaways. In the western sector of the Northern Sea Route each year Kara sea operations were carried out at the mouths of the Ob' and Yenisey, facilitating the strengthening of the economic bonds between Siberia and the European regions of our country and Western Europe. In the eastern sector of the Northern Sea Route the Kolyma and Lena voyages were carried out.

In the course of these operations the seamen acquired their first experience with icebreaker convoys and independent navigation of ships in Arctic ice.

The implementation of ice aerial reconnaissance and the preparation of meteorological and ice forecasts began; information on the ice regime and navigation dangers was generalized. Hydrological and hydrometeorological investigations of the Barents and Kara Seas were carried out; a network of radio stations appeared in the region of these seas and, most importantly, organizational experience was accumulated in the carrying out of major maritime operations under ice navigation conditions.

It should be emphasized that Kara maritime operations for the first time demonstrated the economic importance of the Northern Sea Route for our country and precisely for this reason the problems involved in the organization of these voyages were solved at a high governmental level: at sessions of the Council of Labor and Defense. V. I. Lenin actively participated in the solution of some problems.

In the course of Kara expeditions it became clear that maritime operations under complex arctic conditions must be carried out with the participation of different specialists -- seamen, communications experts, hydrographers, airmen and scientists. This became a distinguishing characteristic of all subsequent work on exploitation of the Northern Sea Route.

Prior to the beginning of the 1930's maritime operations in the western and eastern sectors of the Northern Sea Route were still carried out independently of one another. Practical considerations urgently required the extension of the sea route from the western ports of the country to the shores of the Laptev Sea. This route, passing around the Taymyr Peninsula, was still poorly investigated. Precisely for this reason attempts of the schooner "Velukha" to penetrate into the Laptev Sea through Vil'kitskiy Strait in 1930 and 1931 were unsuccessful.

In January 1932 the Arctic Institute formulated a plan for through navigation along the line of the Northern Sea Route from Arkhangel'sk to Vladivostok. An expeditionary voyage of the icebreaker-steamer "A. Sibiryakov," despite complex ice conditions along individual sectors of the line and the ice damage sustained, ended successfully and after exactly two months the ship reached Bering Strait. This historic voyage demonstrated the possibility of using the Northern Sea Route as a transportation route linking the western and eastern regions of our country.

In 1935 it was finally demonstrated that the Northern Sea Route can be used as a through summer transportation route: the steamers "Vantsetti" and "Iskra" carried out transportation runs from Leningrad to the Far East and the steamers "Stalingrad" and "Anadyr'" made similar voyages in the opposite direction. The voyage of the steamer "Rabochiy" was of great economic importance; during the single navigation season 1935 it made a transportation voyage from Arkhangel'sk to Kolyma and back. This voyage demonstrated the fundamental possibility of transporting cargo from the European regions of our country into the eastern regions of the Soviet Arctic without using the Trans-Siberian Railroad line. A group of ships and fishing vessels was convoyed along the Northern Sea Route in 1936.

However, the work of the Glavsevmorput' in the 1930's involved definite difficulties. This is attributable to the fact that in addition to transportation functions the Glavsevmorput' had to carry out work on the development of industry, trade, exploration and exploitation of natural resources in a wide range of the Asiatic North of our country. Such an expansion of functions of the Glavsevmorput' made it difficult to handle its main task -- exploitation of the Northern Sea Route.

In 1938 the GUSMP was freed of those functions unrelated to its main mission. From that time its principal task became work on transformation of the Northern Sea Route into a reliably operating transportation route. Scientific research activity and work on creating a reliable material-technical base were directed to the implementation of this task. In 1939 it was provided that the Northern Sea Route be developed as an integrated system consisting of a number of highly important and inseparably interrelated links: control of the transportation process, icebreaker fleet, navigational-hydrographic work, scientific operations work, aerial support and communications.

During the years of the Great Fatherland War the Northern Sea Route was a highly important transportation line in the Soviet North.

In 1953 the Main Administration of the Northern Sea Route of the USSR Council of Ministers was transformed into a main administration of the Ministry of the Maritime Fleet. In 1960 the polar aviation under the control of the GUSMP was turned over to the Ministry of Civil Aviation. Since 1963 the hydrometeorological support of navigation and aviation in the Arctic has been the responsibility of the Main Administration of the Hydrometeorological Service of the USSR Council of Ministers. In 1964 the GUSMP was abolished and regional functions were delegated to other administrations of the Ministry of the Maritime Fleet. Since that time the direction and coordination of the fleet's operations in the Arctic has been the responsibility of the Main Administration of Navigation, Ministry of the Maritime Fleet. Beginning in December 1970 these functions were delegated to the newly organized Administration of the Northern Sea Route (Administratsiya Severnogo Morskogo Puti -- ASMP) under the Ministry of the Maritime Fleet. The creation of the ASMP made it possible to monitor the planning and implementation of specific scientific and practical measures vitally important for development of the Northern Sea Route.

Icebreaker Fleet

The icebreaker fleet developed in accordance with practical needs. During the 1920's our country had the icebreaker-steamers "Yermak" and "Krasin," each with a power of about 10 000 HP and the icebreakers "F. Litke" and "Lenin" with a power of 7000-7500 HP. The regular use of icebreakers in the convoying of cargo ships in the Arctic began in 1929.

Early in the 1930's the Glavsevmorput' validated the desirability of building new Soviet icebreakers. The first Soviet-constructed icebreaker, the "I. Stalin," with a steam power plant of 10 000 HP, was put into operation in 1938. Three other icebreakers of this type were put into operation during the years 1939-1941.

The experience in the operation of icebreakers during the first arctic navigation seasons revealed that they were highly promising in ensuring the continuous movement of transport ships. Beginning with the navigation season 1935 icebreakers have been used in the Arctic in a planned and effective manner: with allowance for impending tasks the distribution of icebreakers along the entire Northern Sea Route has been determined in advance. The use of icebreakers favored the clear organization of movement of the transportation fleet: convoying, discipline during movement of the convoy, a good knowledge of the navigation region, implementation of regular ice reconnaissance and reliable radio communications.

A new rise in the development of the Soviet icebreaker fleet began during the postwar period. During the period 1954-1956, the USSR contracted for the construction of three icebreakers of the "Kapitan Belousov" type with a diesel-electric engine with a power of 10 500 HP in Finnish shipyards. Icebreakers of this type, having screws at the prow, had performed well in freezing nonarctic seas during work in continuous ice, but their operation in arctic ice was not entirely successful.

As a result of aging of steam-powered icebreakers, the cargo volume increase in the Arctic and the organization of year-round navigation in freezing nonarctic seas, during the period 1960-1969 the USSR contracted with Finland for the construction of five diesel-electric icebreakers of the "Moskva" type with a power of 26 000 HP. These icebreakers have performed well in the convoying of ships in arctic seas. They operate virtually year-round: after work in the Arctic they convoy ships in the Baltic Sea and in the Sea of Okhotsk.

The world's first nuclear-fuel icebreaker, the atomic-powered "Lenin," with an engine power of 44 000 HP, participated in the arctic navigation season 1960. Its operation indicated that an icebreaker of such a class has a high capacity for penetrating the ice and good maneuverability under complex ice conditions. The principal merit of atomic icebreakers is their great autonomy and this is exceptionally important when navigating in the ice.

During the 1970's the USSR continued to contract with Finland for the building of arctic icebreakers. During 1974-1976 three diesel-electric icebreakers of the "Yermak" type with a power of 41 000 HP were constructed in Finland. The "Kapitan Sorokin," with a diesel-electric engine with a power of 22 000 HP, appeared in arctic seas for the first time in the summer navigation season 1977. This vessel was constructed for the purpose of operations in regions with limited depths. In the years which followed three other icebreakers of this type were constructed. Icebreakers of the "Yermak" and "Kapitan Sorokin" types are being successfully operated both on arctic routes and in freezing nonarctic seas.

A noteworthy event in exploitation of the Northern Sea Route was the construction of the atomic-powered "Arktika" with a power of 75 000 HP. It has performed excellently during the convoying of transport ships during both the summer and winter arctic navigation seasons. The possibilities of icebreakers of this class were demonstrated for the first time in the scientific-practical experimental voyage of the atomic-powered "Arktika" to the north pole in

August 1977 and then in the high-latitude transarctic convoying of the diesel-electric "Kapitan Myshevskiy" by the atomic-powered "Sibir'" in May-June 1978. The possibilities for carrying out arctic navigation were substantially improved with the construction of the third icebreaker of this series -- the "Rossiya" atomic-powered icebreaker.

Thus, during the years of mastery of the Northern Sea Route there was an unprecedented change in the icebreaker fleet of our country. There was an improvement in the maneuvering qualities of the icebreakers, and as was especially important, the living conditions became more comfortable. The icebreakers have modern motion picture theaters, libraries, classrooms, gymnasia, swimming pools, saunas and medical facilities.

The "icebreaker-ship" transportation-technological system will predominate, or at least persist, in the long run. In connection with the need for a gradual lengthening of the navigation season along the entire path of the Northern Sea Route, the problem arises of the construction of new icebreakers of a large size capable of sailing under more complex ice conditions.

Ice Navigation Cargo Fleet

A cargo fleet suitable for ice navigation conditions is an indispensable condition for the successful implementation of arctic navigation. The Soviet ice navigation cargo fleet is constantly being improved and supplemented. It should be mentioned that the fleet in the Arctic in the 1920's consisted primarily of old ships not adapted for ice navigation and several steam-driven icebreakers, such as the "Malygin," "A. Sibiryakov," "Sadko" and "G. Sedov."

Already in the 1930's work was carried out for creating a series of transport ships specially adapted for Arctic voyages. In 1936 a steam-driven timber-carrier of the ice class, of the "Arktika" type, and a freighter of the ice class, of the "Volga" type, were constructed.

The construction of new ships for the Arctic was planned in August 1938. The first ice-breaking steamer "S. Dezhnev," was put into operation that same year. Ships of the "Anadyr'" and "Igarka" types were constructed during these same years.

During the 1940's-1950's the basis for the transport fleet sailing in the Arctic was timber-carriers constructed before the war, as well as vessels of the "Andizhan," "El'ton" and "Liberty" type. Ships of the ice class of the type "Kapitan Gastello," "Donbass," "Saltykov-Shchedrin," "Stavropol'" and "Chulyy" were put into operation. At the same time ships of a strengthened ice class of the types "Dneproges" and "Stanislavskiy" were constructed. An important event in the mastery of the Northern Sea Route was the construction in 1954-1957 of five ships of a strengthened ice class of the "Lena" type. During the period from 1961 through 1972 13 ships of the ULA (strengthened ice class) class of the "Amguema" type were constructed for the arctic route. These vessels constituted the basis for the transport fleet in the Arctic. Supplementing these, in the years which followed large series of ships of a strengthened ice class of the types "Volgoles," "Igarkales," "Povenets," "Pioner," "Baskunchak," "Samotlor," "Kapitan Panfilov," "Dmitriy Donskoy" and others. The increase in power and strength characteristics of the ship hulls made possible a gradual increase in the speed of convoys in continuous ice. This circumstance, as well as the increase in the cargo capacity of ships, made possible a considerable increase in the freight-handling capacity of the transport fleet in the Arctic.

A further enhancement of effectiveness of arctic transport will be favored by promising cargo-carrying ships suitable for navigation in the Arctic of the "Noril'sk" type with a dead weight of 15,000 tons, timber-carrying vessels of the "Mikhail Strekalovskiy" type, and finally, ships with a dead weight of about 25,000 tons, which in their parameters will correspond to the characteristics of new powerful icebreakers. A factor of great importance will be the introduction of a lightering system for transport in the Arctic. Its desirability is dictated by the fact that the delivery of freight to ports and landings situated on arctic rivers involves great expenditures. The latter is caused by low norms for cargo-handling work at river points and the use of underloaded sea ships due to shallow depths.

A fundamentally new step in servicing inaccessible polar stations will be the appearance on arctic routes of a supply ship with a helicopter pad. The desirability of creation of such a vessel is dictated by the complex ice conditions and the shallow depths at the approaches to the polar stations, the absence of on-shore mechanization and the great expenditures of physical labor when unloading cargo in roadsteads.

The construction of these promising arctic vessels will provide new conte to the entire operation of the fleet in the Arctic.

Arctic Ports

The very first years of work in the Arctic indicated that the exploitation of the Northern Sea Route is impossible without the development of port facilities. This problem was raised for the first time in 1922 at an interdepartmental arctic conference. Already in 1923 on the Yenisey work was completed on construction of Ust'-Port. In 1929 work began on construction of the port of Igarka. Early in the 1930's wharves and coal unloading facilities appeared at Dudinka, at Dikson, at Tiksi, at Ambarchik and at Provideniya. A governmental decree of August 1938 mentioned the acceleration of work on the technical development of arctic ports and an increase in the handling capacity of their coal facilities. The port of Pevek was constructed in 1942-1946 and thus already by the late 1940's the modern distribution of arctic ports was formed. In the years which followed, in accordance with the increase in the volume of cargo carried, there was a further expansion of wharves in arctic ports and they were outfitted with mechanized facilities with a quite high handling capacity.

We feel that ensuring the operation of arctic ports under ice conditions is one of the key problems whose resolution governs the possibility and economic effectiveness of lengthening of the navigation season on the Northern Sea

Route. However, this is one of the least studied problems because during recent decades the emphasis has been on investigation of the conditions for ice navigation on the routes in arctic seas. More attention must be devoted to the development of ports so that in the future, with the lengthening of the navigation season in the Arctic, it will be possible to avoid economic, technical and organizational difficulties.

Polar Hydrography

It is difficult to visualize the Northern Sea Route without navigational-hydrographic assurance of the safety of navigation. Soviet polar hydrographers have transformed the Northern Sea Route. It is fitting to recall that early in the 1920's navigators in the Arctic had 18 navigation charts, of which 14 covered the Kara Sea and 2 covered the other Soviet arctic seas; there were no sailing directions; there was not a single beacon along the route and not one lighthouse; there were only 15 navigational aids along the route.

Now navigators have at their disposition hundreds of reliable sea charts at different scales compiled on the basis of new highly accurate and detailed hydrographic studies. Beginning in 1930 the sailing directions for arctic seas have been constantly revised and corrected. Navigators are informed well in advance concerning any change in navigation conditions. Highly precise radionavigation systems have been established along the route, also serviced by automatic radio beacons, radar orientation systems, together ensuring determination of ship position under any visibility and weather conditions.

The hydrographic and piloting fleet can no longer be recognized. In place of the antiquated schooners with wooden hulls depth-sounding work is now carried out using specially equipped hydrographic vessels of the strengthened ice class of the "Dmitriy Ovtsyn" and "Fedor Matisen" types. The hydrographic icebreakers "Petr Pakhtusov" and "Georgiy Sedov" operate under especially complex ice conditions. Modern hydrographic investigations are based on the use of highly precise measurement instruments and the introduction of automation of production processes.

Polar hydrographers are not content with what they have achieved and are constantly improving their investigations, as is expressed in their intensification, a substantial increase in the quality and reliability of measurements, an increase in the effectiveness of use of the results of investigations and an acceleration of the processing of materials and map compilation. In the Arctic it is particularly important to intensify hydrographic investigations because the natural conditions in this region are extremely unfavorable and it is necessary to increase the productivity of labor in order to improve the operational possibilities of a hydrographic expedition. An important condition for progress in polar hydrography is a decrease in the cost of both hydrographic measurements and work on the navigational outfitting of the route.

Role of Science

Navigation in the Arctic was always very closely related to hydrometeorological science. Experience has demonstrated that the effectiveness of adoption of decisions concerning work of the arctic fleet is dependent on a knowledge of the current and prognostic information on ice, meteorological and hydrological conditions of navigation. As a result of this any practical measure in the Arctic, from long-range planning of arctic navigation to the carrying out of an individual sea operation, is carried out with allowance for scientifically validated recommendations.

The scientific basis for their preparation is the results of long-term investigations by different specialists of the Arctic and Antarctic Scientific Research Institute. It has now been possible to establish the peculiarities of distribution of such characteristics of the ice cover in arctic seas as continuity, thickness, degree of destruction, hummocking, fragmentation and compression. Studies have been made of the processes of melting, growth and dynamics of the ice. Specialists have generalized long-term observations of level variations, waves and sea currents in arctic seas. Navigators are very familiar with the patterns of distribution in arctic seas of wind direction and velocity, fogs, visibility, air temperature and many other meteorological parameters. The results of these investigations have been given in a number of scientific-practical aids convenient for practical use. Investigations of the ice conditions for navigation and the processes of interaction between ships and icebreakers and the ice cover, carried out at the Arctic and Antarctic Scientific Research Institute, are of particular importance for practical work.

There is a constant deepening of investigations of thermal and dynamic processes in the ice cover, water layer and atmosphere over extensive expanses of arctic seas. This has made it possible to create methods for computing and predicting different hydrometeorological characteristics limiting the navigation of ships and icebreakers. Each year specialists at the Arctic and Antarctic Scientific Research Institute compile three long-range ice and meteorological forecasts, which when necessary and possible are made more detailed and refined. These forecasts are the initial conditions for compiling an arctic navigation plan. The operational control of work of the fleet in the Arctic rests on ice and meteorological forecasts with an advance time of 3-8 days and forecasts of sea level along segments of the route with limiting depths. The forecasts prepared by the Arctic and Antarctic Scientific Research Institute and the scientific-operational teams at sea operations headquarters for the most part correctly orient seamen concerning the anticipated development of hydrometeorological processes.

Taking into account the volume of cargo, which increases with each passing year under conditions of constant lengthening of the navigation season in the Arctic, the requirements on hydrometeorological forecasts will increase. These requirements, in particular, relate to the reliability, greater advance time and greater detail of forecasts during the summer. It is particularly important to activate study of hydrometeorological and ice conditions during winter and on this basis to develop corresponding methods for making forecasts for different times in advance.

The basis for any measures in the Arctic was always technical-economic investigations of the problems of development of the Northern Sea Route, including the peculiarities of distribution of productive forces in the arctic zone, the working out of suitable schedules for the handling of freight, optimum transport-technological systems, improvement in the organization of operation of the fleet, technical operation of the icebreaker fleet, improvement in the tactics for ice navigation, etc. This work was successfully carried out by the Moscow Division, Arctic and Antarctic Scientific Research Institute, and since 1963 by the Soyuzmorniiproyekt and Central Scientific Research Institute of the Maritime Fleet. An important event was the creation, in 1974, of the Murmansk Affiliate, Central Scientific Research Institute of the Maritime Fleet, specializing in study of technical-economic problems of arctic navigation.

Ice Reconnaissance

Effective navigation in the Arctic without a knowledge of ice conditions along the route is impossible. This circumstance was responsible for the organization of ice reconnaissance in arctic seas in the 1920's-1930's. Its regular implementation over great expanses became possible due to the use of aviation. Precisely by means of aviation our country in a relatively short time was able to master navigation in the Arctic.

Tactical aerial ice reconnaissance is now being carried out for the purpose of ensuring the navigation of ships and icebreakers. An important element in the system for the collection of information is strategic monthly and 10-day ice aerial reconnaissance. An ice map, sent by phototelegraph, either from aboard an aircraft, or from a nearby radio center, is a highly important factor in the intensification of transportation processes. Equally important is helicopter ice prospecting, carried out from aboard an icebreaker.

The last two decades have been characterized by substantial changes in ice reconnaissance methods. In addition to visual aerial reconnaissance, use has been made of aircraft with side-scanning radar sets with direct simultaneous transmission of the image of ice conditions to an icebreaker. The creation of a radar instrument for measuring ice thickness along the aircraft flight line was of great importance; this made possible a considerable improvement in the quality of determination of the age characteristics of the ice. An important means for obtaining ice information at the present time is artificial earth satellites.

A further development of the system for the collection and dissemination of ice information will be accomplished with allowance for the need for carrying out operations in arctic seas during winter. The regularity of obtaining ice information regardless of illumination and weather conditions, as well as its routine dissemination to the user -- these are the principal requirements of any future system for carrying out ice prospecting.

Evidently these requirements can be ensured with automation of the process of collection of ice information and availability of instruments for this purpose.

Communications

Arctic communication ensures reliable interaction of all links in the Northern Sea Route system. Its development occurred in accordance with the rates of development of other means for the support of arctic navigation. Radio stations at Yugorskiy Shar, at Mare-Sala and Dikson were inherited from czarist Russia. In the arctic navigation season of 1920 many ships did not have shipboard radio stations and conversations between ships were by flag. Already in the 1920's-1930's radio stations were constructed at Obdorsk, Ust'-Yeniseysk, Dudinka, Novyy Port, Matochkin Shar, on Cape Shalaurov, on Franz-Josef Land, on Vrangel' Island, on Cape Zhelaniye and on Cape Chelyuskin. Later the network of radio stations was constantly expanded.

Receiving-transmitting radio stations of the State Committee on Hydrometeorology and the Ministry of the Maritime Fleet are now distributed along the Northern Sea Route. The technical outfitting of arctic radio centers is being constantly improved. Communication with ships and polar stations is ensured not only via the radio channel, but also via telegraphic-telephonic communication lines. The transmission and reception of cartographic information over considerable distances is ensured regularly and with a good quality. Conversations via radiotelephone between the personnel of the Marine Operations Headquarters and the captains of icebreakers have become an ordinary happening. However, sometimes the geophysical conditions for the propagation of radio waves in the Arctic are unfavorable and this has a negative effect on the speed of transmission of radio communications. Taking this into account, as well as the further intensification of traffic along the Northern Sea Route, the problem of creating space communication facilities in the Arctic is becoming timely.

Principal Results and Trends

Thus, all links in the Northern Sea Route system have been constantly improved in dependence on the rates of economic development of the arctic zone of our country. A distinguishing characteristic of this process is a constant increase in the volume of arctic cargo, and as a result of this, a gradual increase in the duration of the arctic navigation season and an intensification of operation of the fleet as a result of an increase in the optimum rate of convoying of ships, proper grouping of ships in specific convoys, corresponding icebreaker support, carrying out of multiple voyages of cargo ships during the course of one arctic navigation season, artificial breaking of the shore ice in key sectors of the route. Successes in the exploitation of the Northern Sea Route became possible due to scientific and technical progress in all links of the system.

An autumn-winter navigation season in the Kara Sea represented a fundamentally new stage in the exploitation of the Northern Sea Route. Whereas in the early 1970's only a few ships participated in the lengthened navigation season, in recent years there have been several dozen ships. An important technological innovation was the delivery of cargo and its unloading on the ice shelf of the western coast of the Yamal Peninsula in March 1976. The creation of such a transport-technological scheme made it possible to avoid the difficult summer roadstead unloading in the shallow-water regions of the coast and accelerate considerably the rates of cargo-handling work.

The use of the "Kapitan Sorokin" icebreaker on the Yenisey made it possible to carry out experimental winter transport work at Dudinka in April-May 1978 during which a variety of problems related to the implementation of the winter navigation season in the Arctic were worked out. Such experience is constantly being accumulated and studied.

The tasks defined by the resolutions of the 26th CPSU Congress are spurring all the participants in the technological process of convoying of transport ships under ice conditions to a gradual expansion of winter operations in the western region of the Soviet Arctic. The task is exceptionally complex. The conditions for its successful realization are the balanced development of all the links in the Northern Sea Route system, fundamental and practical investigations of the problems involved in winter arctic navigation with the gradual implementation of experimental voyages along key segments of the arctic route.

New technology is being created for the successful solution of these problems. However, even the most modern technology will be of no avail without people. Accordingly, the principal link in solution of transportation problems is and will remain people -- polar seamen. They assiduously hand down the experience of ice voyages, accumulated over long years, to young specialists. This is a guarantee of present and future successes.

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SIX DECADES OF OCEAN RESEARCH

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[Article by A. S. Monin, corresponding member, USSR Academy of Sciences, and K. N. Fedorov, doctor of physical and mathematical sciences]

[Text] On 10 March 1921 V. I. Lenin signed a decree of the Council of People's Commissars on the organization of the "Floating Sea Institute" (Plavmornin) and the first sea expeditions of this institute, first on the icebreaker "Malygin" and then on the first Soviet research ship "Persey." This date also became the birthday of Soviet oceanology.

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The modern science of the ocean is one of the leading branches of the earth sciences which has gone completely beyond the limits of the descriptive stage and is now supported by the latest methods of the precise sciences. Today's oceanology has at its disposal ships which can operate over great distances, underwater self-contained and towed vehicles, artificial earth satellites, powerful electronic measurement gear, optical and acoustic research tools.

To be sure, as in any rapidly developing field of human activity, oceanology has its difficulties, but the path which it has traveled from the heroic beginnings of the tiny "Persey" to the present major oceanic expeditions with the participation of many ships (in many cases from different countries) and with the use of artificial earth satellites is truly astonishing. The experience of the Soviet Union can serve as an example for many developing countries which have recently become independent. They, like the Soviet Union 60 years ago, must for many years ahead plan their active participation in exploitation of the wealth of the world ocean.

The progress of Soviet oceanology during these decades has not been uniform in all directions. In order to confirm this it is sufficient to turn the pages of No 5 of the journal OKEANOLOGIYA (Oceanology) for 1967 which contains articles by leading oceanologists who summarized the results of Soviet investigations of the ocean during the preceding 50 years. After comparing them with the present status of science, one cannot but see that during the last 15 years the rates of development have been particularly great in such fields as ocean hydrophysics, study of its synoptic variability and the dynamics of sea currents, numerical modeling in dynamic oceanology and marine biology, laboratory experiments in the field of geophysical hydrodynamics, recent geotectonics, investigations of ocean climate and paleooceanology. But, to be sure, the basis for these qualitative jumps was the slow accumulation of fundamental scientific results in the preceding years.

It is noteworthy that the school of "Persey" scientists, training such remarkable investigators as Academicians A. P. Vinogradov, L. A. Zenkevich, V. V. Shuleykin and Ye. M. Kreps, Corresponding Member USSR Academy of Sciences V. G. Bogorov, Professors I. I. Mesyatsev, N. N. Zubov, A. D. Dobrovol'skiy, S. V. Bruyevich, M. P. Klenova, V. B. Shtokman and many others, bringing fame to Soviet science, immediately set as their goal a fundamental approach to study of the world ocean in the entire complex of scientific disciplines. Physics, chemistry, biology and marine geology received a powerful impulse in their development from the very first voyages of the "Persey," "Malygina," "Sibiryakova," "Sadko" in our northern seas.

Investigations of the ocean came to be characterized by the formation of creative groups of scientists, coming together for solution of various problems of importance to the national economy. For example, the Institute for Study of the North, established in 1925, by 1930 had developed into the All-Union Arctic Institute, and by 1958 it had already become the Arctic and Antarctic Scientific Research Institute (AANII). The Plavmornin in 1929 was transformed into the State Oceanographic Institute -- the first GOIN, during its short lifetime playing an important role in the formation of Soviet oceanology. The All-Union Scientific Research Institute of Fishing and Oceanography (VNIRO), established in 1933, can be regarded as the "heir" of the Plavmornin; since that time it has been transformed into the leading institute in the field of fishing oceanology and has divisions in the different seas washing the shores of our country. The present-day State Oceanographic Institute (GOIN) has been in operation since 1943; its work has greatly facilitated the improvement of the weather forecasting service. In 1929 the Marine Hydrophysical Station was established; in 1948 it was transformed into the Marine Hydrophysical Institute, USSR Academy of Sciences (in 1963 it was moved from Moscow to Sevastopol' and became part of the Ukrainian Academy of Sciences). The Oceanology Laboratory, USSR Academy of Sciences, in 1946 was transformed into the Institute of Oceanology, which in 1967 was assigned the name of its first director -- the well-known oceanologist P. P. Shirshov. The institute, which now has 2000 specialists, rightfully has been the leader of multisided investigations of the ocean in our country and acquired world fame as one of the leading oceanological institutes of the world.

Communications in newspapers on distant expeditionary voyages of our scientific research ships have long been customary. From the tiny heroic "Persey" of the 1920's, after the 62 scientific voyages of the flagship of the Soviet oceanographic fleet, the "Vityaz'," which over the course of 30 years ran 750,000 miles), the flag was passed to the scientific research ship of the USSR Academy of Sciences, the "Akademik Kurchatov," during a period of 16 years making 34 scientific voyages, and finally, the most modern of the Soviet "floating institutes" -- the "Akademik Mstislav Keldysh." The scientific fleet of the Soviet Union now has many tens of scientific research ships.

There was a remarkable evolution of the very approach to the organization of expeditionary work which has been clearly manifested during the last 30 years. It has been associated with the changeover from the descriptive-reconnaissance ("geographic") stage to the analytical stage, whose center of gravity came to be a study of the complex nature of processes and phenomena. In other words, oceanography in the first half of the century was in need of multisided expeditions of the survey-reconnaissance type, whereas oceanology -- a science of the end of our century -- required purposeful specialized expeditions, including the elements of an experiment in the ocean itself. The principle of multisided studies, initially being interpreted as the need to combine on each expeditionary voyage observations, measurement and collection of data in the full range of oceanographic disciplines, came to be understood as a preplanned organic combination of investigations only of those problems which are necessary for solution of different specific problems. For example, purposeful sea and biological expeditions now include hydrophysical and hydrochemical work only to the degree that it is necessary for solving the formulated biological problems. Ever-increasing importance is now being given to the correlation between in situ observations and theory. That is why, while broadening the capabilities of the expeditionary fleet, Soviet oceanologists are not forgetting the broadening of theoretical, model and experimental investigations in the ocean.

A graphic example of such an approach is the hydrophysical experiment "Poligon-70," carried out in the tropical Atlantic in 1970 by the personnel of several institutes and departments headed by the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences (ZEMLYA I VSELENNAYA, No 3, pp 6-13, 1971 -- Editor). Here we can also mention an underwater expedition for study of the Red Sea rift, organized in 1980 by the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences (ZEMLYA I VSELENNAYA, No 5, pp 57-59, 1980 -- Editor). The results of the Soviet "Poligon-70" expedition later stimulated the carrying out of the Soviet-American expedition "POLYMODE" for studying the physical nature and characteristics of synoptic eddies in the ocean (ZEMLYA I VSELENNAYA, No 2, pp 65-67, 1977 -- Editor).

There is not a single scientific field which can be developed successfully without means for the exchange of information and especially without periodic publications. Specialized periodicals are regularly publishing articles devoted to investigation of the ocean and several publishing houses issue Russian and translated literature in the field of oceanology. During the last 60 years Soviet scientists have published such fundamental works in the field of oceanology as FIZIKA MORYA (Marine Physics), by V. V. Shuleykin, the two-volume MORSKOY ATLAS (Marine Atlas), the 10-volume monograph TIKHIY OKEAN (Pacific Ocean) (to a considerable degree based on the results of voyages of the "Vityaz'"), AKUSTIKA OKEANA (Ocean Acoustics), the three-volume ATLAS OKEANOV (Atlas of the Oceans) and the 10-volume monograph OKEANOLOGIYA (Oceanology), written during recent years by a group of specialists at the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences. Soviet scientists have written books representing the world's first publication of the results of investigations in completely new scientific directions. Examples are the monographs POGONOFORA (Pogonophora), by A. I. Ivanov, awarded the Lenin Prize in 1961, IZMENCHIVOST' MIROVOGO OKEANA (Variability of the World Ocean), by A. S. Monin, V. M. Kamenkovich and V. G. Kort, TONKAYA TERMOKHALINNAYA STRUKTURA VOD OKEANA (Fine Thermohaline Structure of Ocean Waters), by K. N. Fedorov. Many of these books have been published by leading foreign publishing houses. Soviet oceanologists are active participants and frequent organizers of many international symposia and conferences on different problems in study of the ocean.

The school of Soviet marine biology, forming its traditions with the works of N. M. Knipovich and K. M. Deryugin and closely associated with fishing oceanography, is widely known throughout the world. The outstanding Soviet biologist L. A. Zenkevich, whose scientific interests were concentrated in the field of fauna in the abyssal parts of the ocean, was an adherent of an integrated approach to the entire animal world of the ocean. It was based on the science of the biosphere which made it possible to raise the question of the biological structure of the world ocean and in turn made it possible to combine quantitative methods in marine biology with the zoogeographic approach. V. G. Bogorov, Z. I. Filatov, V. A. Yashnov, B. P. Manteyfel' and many others worked productively in this field of oceanology for many long years. The major work of L. A. Zenkevich entitled BIOLOGIYA MOREY SSSR (Biology of Seas of the USSR) was the most popular book of several generations of marine biologists. While actively working in the field of investigation of plankton and biological productivity of the ocean as a whole, V. G. Bogorov trained a large group of scientists. Now, under the direction of M. Ye. Vinogradov, they are successfully continuing investigations of primary biological production, photosynthesis and the primary links of the food chain in the ocean.

The works of T. S. Rass, G. V. Nikol'skiy and N. V. Parin have won deserved recognition in the field of ichthyology. The works of T. S. Rass were devoted to investigation of the fish resources of the seas washing the shores of the USSR and the possibilities of supplementing these resources by the acclimatization of fish species. In the Soviet Union during recent years, under the direction of M. Ye. Vinogradov and V. V. Menshutkin, there has been successful development of investigation of the ecosystems of zones of upwelling and frontal zones in the world ocean.

The development of physical oceanology in the Soviet Union in the early years was closely associated with the investigations of N. N. Zubov, Vs. A. Berezkin, V. V. Shuleykin, V. B. Shtokman. Their works laid the scientific basis on which specialized directions in physical investigations of the ocean -- thermodynamic, hydrodynamic, acoustic, optical, etc. -- then began to develop. Investigations of currents and mixing in the ocean on the basis of a rigorous physical and hydrodynamic theory did much to facilitate the studies of V. B. Shtokman, which are now becoming classic, such as "Theory of Equatorial Countercurrents in the Ocean" or "Determination of Stationary Currents and Fields of Masses Caused by the Wind in a Baroclinic Sea." The modern school of marine dynamics, developing at the Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, is widely known abroad. Placing fundamental problems of the dynamics of general circulation of the ocean at the center of attention, since the mid-1960's this school has begun to specialize in investigation of marine turbulence, internal waves and interaction between the ocean and the atmosphere and since the early 1970's -- in study of the microstructure and fine thermohaline structure of waters, investigation of ocean fronts and synoptic eddies.

Among the students of V. V. Shtokman successfully continuing research work at the present time in the field of dynamics and thermodynamics of ocean waters we should mention such well-known scientists as R. V. Ozmidov, V. M. Kamenkovich, L. M. Fomin, K. N. Fedorov. Professor N. N. Zubov, who for about 10 years headed the State Oceanographic Institute and for many years taught at Moscow State University, created a whole school of researchers who continued work on study of the thermodynamic characteristics of sea water. A study of sea ice initiated by N. N. Zubov as early as the 1930's was successfully continued at the Arctic and Antarctic Scientific Research Institute. Physical geography and climatology have successfully developed parallel with theoretical hydrophysical investigations due to the works of A. D. Dobrovol'skiy, V. G. Kort, V. A. Burkov, V. N. Stepanov, and others.

There are specific directions in physical oceanology in which significant successes have also been attained in recent years: turbulence and microstructure in the ocean (A. S. Monin, R. V. Ozmidov, V. S. Belyayev, V. T. Paka), surface waves (V. V. Shuleykin, Yu. M. Krylov, I. N. Davidan, V. Ye. Zakharov); internal waves (Yu. Z. Miropol'skiy, K. D. Sabinin, Ye. N. Pelinovskiy); long waves and tsunamis (L. N. Sretenskiy, S. S. Voyt, S. L. Solov'yev); tides (L. N. Sretenskiy, K. D. Tiron, B. A. Kagan); numerical modeling of general circulation in the ocean (A. S. Sarkisyan; D. G. Seidov, D. V. Chalikov); investigation of synoptic eddies (A. S. Monin, L. M. Brekhovskikh, V. M. Kamenkovich, V. G. Kort, M. N. Koslyakov); fine thermohaline structure of hydrophysical fields in the ocean (K. N. Fedorov, A. S. Monin, G. I. Barenblatt); investigations of the ocean by aerospace methods (B. A. Nelepo, K. N. Fedorov).

Specialization in the field of physical oceanology continues to deepen. Today even extremely specialized physical results rapidly find application in related branches of oceanology and in solving different practical problems. However, more instructive in the progress of physical oceanology is not the growing specialization, but a completely new point of view on the organization of physical measurements in the ocean. The new, so-called "polygon" organization of measurements is very closely associated with the concept of purposefulness of expeditionary work in the ocean, as already mentioned. In this case "polygon" means a specially selected region or sector in the ocean where a well-devised complex of physical measurements of a definite duration, directed to solution of preformulated problems, is organized. In the case of polygon measurements there can be a correction of the scientific program on the basis of a speedy analysis of the arriving information, and this imparts an experimental and more flexible character to physical measurements in the ocean.

Marine optics and hydroacoustics proceeded along independent paths of development during the six decades. Naturally related to physical oceanology, these directions nevertheless experienced a strong influence from different practical spheres and therefore they developed particularly intensively around practical problems. Investigations of the optical properties of sea water and the laws of light propagation in the ocean, initiated by V. V. Shuleykin, were then developed extensively by M. V. Kozlyaninov, G. G. Neuymin, K. S. Shifrin, A. P. Ivanov. During recent years there has been intensive development of investigations of photoluminescence (G. S. Karabashev) and bioluminescence (I. I. Gitel'zon), who discovered new possibilities for solving physical and biological problems in oceanology.

Investigations of the propagation, scattering and absorption of sound in the ocean medium against a background of natural noise of the ocean from the very beginning were headed by L. M. Brekhovskikh. Already in 1949 he discovered the property of superdistant sound propagation in an "underwater sound channel," formed by the specific distribution of temperature and salinity in the ocean. In 1953 the Acoustics Institute was established in the USSR. At the Acoustics Institute (AKIN) these investigations were concentrated around practical problems. An important stimulus for these investigations was obtained in 1961 after the commissioning of two specialized acoustic ships -- the twins "Sergey Vavilov" and "Petr Lebedev." In 1976 a group of specialists at the Acoustics Institute, headed by L. M. Brekhovskikh, was awarded the USSR State Prize for the monograph AKUSTIKA OKEANA (Ocean Acoustics). Among the recipients of the USSR State Prize are such well-known specialists in the field of hydroacoustics as Yu. P. Lysanov, I. B. Andreyev, R. F. Shvachko, Yu. Yu. Zhitkovskiy.

Geological and geophysical investigations at sea began to develop rapidly in Soviet times. The first ideas concerning bottom relief and types of bottom sediments (for the most part for the Black Sea) were already formed prior to the Great Fatherland War in the works of N. I. Andrusov, A. D. Arkhangel'skiy, N. M. Strakhov. In the Barents, Kara and other northern seas a study of bottom sediments was initiated at that time on the expeditions of the "Persey" under the direction of Ya. V. Samoylov. The Hakkel and Lomonosov Ridges were discovered in the Arctic Ocean.

The postwar development of marine geological investigations is associated primarily with the regular voyages of the "Vityaz'" -- first in the Far Eastern marginal seas, and after 1957 -- in the open ocean. In the Pacific, Indian and Atlantic Oceans (including Antarctic regions) it was possible to investigate many large bottom relief forms -- underwater ridges, mountains, trenches, faults. Geomorphological and tectonic maps of the oceans were compiled; the thickness and physical parameters of the sedimentary stratum and the ocean crust were studied in different tectonic regions; the distribution of geophysical fields in the Pacific Ocean was plotted on a map; the deep geology of the Caspian, Black and Mediterranean Seas was investigated in detail.

During recent years much work has been done on problems relating to processes of sedimentation, distribution of types of sediments and sedimentary formations, rates of sedimentation, lithology and geochemistry of the sedimentary stratum (P. L. Bezrukov, A. P. Lisitsyn, and others; a study has been made of the stratigraphy of Cenozoic ocean deposits on the basis of diatomaceous algae (A. P. Zhuze, foraminifera (Kh. M. Saidova, V. A. Krasheninnikov); determinations of radiochronological and paleomagnetic ages were made; geochemical investigations have been made on a broad scale. Investigations laying the basis of modern knowledge concerning oceanic ferromanganese nodules (P. L. Bezrukov and G. N. Baturin) have assumed great practical importance, as is true also of investigations of the petroleum and gas content of Soviet seas (Ya. P. Malovitskiy and A. A. Geodekyan) carried out in recent years.

A considerable success of Soviet marine geologists and geophysicists during the last 10-15 years has been their active participation in the development of the modern scientific theory of structure and evolution of the earth, known as the tectonics of lithospheric plates. According to this theory, the earth's lithosphere is broken down into plates moving along the surface of the planet at the rate of several centimeters per year. During the geological history of the earth, which occupied hundreds of millions of years, such movements can attain thousands of kilometers. This phenomenon, in particular, explains the slow drift of the continents, leading, for example, to the drifting of the American continent away from Europe and Africa, to the expansion of the Indian Ocean and contraction of the Pacific Ocean (ZEMLYA I VSELENNAYA, No 5, pp 20-27, 1974 -- Editor).

Soviet scientists have done much for the development of this fertile concept. It is sufficient to mention the names of A. V. Peyve, O. G. Sorokhtin, P. N. Kropotkin, R. M. Demenitskaya, L. P. Zonenshayn, A. P. Lisitsyn and S. A. Ushakov. Continuing the ideas of O. Yu. Shmidt, a group consisting of A. S. Monin, O. G. Sorokhtin and V. P. Keondzhyan developed a theory of the evolution of the earth's deep layers explaining the mechanism of the tectonics of lithospheric plates. At the Institute of Oceanology, USSR Academy of Sciences, specialists for the first time developed and in 1973 published a model of structure of oceanic lithospheric plates now adopted throughout the world. On its basis it was possible to explain the reason for formation and configuration of the mid-oceanic ridges and to construct maps of the thickness of lithospheric plates under all the oceans (ZEMLYA I VSELENNAYA, No 4, pp 38-41, 1980 -- Editor). Investigation of the Red Sea rift zone by means of submergible vehicles, undertaken in 1980 by scientists of the Institute of Oceanology, yielded much interesting evidence of spreading of the ocean floor. This served as excellent confirmation of the developed theory.

Investigations in the field of chemistry of the seas and oceans began to be carried out systematically in the USSR beginning with the first Plavmornin expeditions. Several directions were pursued in these investigations: chemical structure of waters of the world ocean (S. V. Bruyevich, O. A. Alekin); chemistry of biogenous elements (V. N. Ivanenkov); chemistry of bottom deposits (N. M. Strakhov, E. A. Ostroumov, I. I. Volkov); chemistry of water contaminations (A. I. Simonov, M. P. Nesterova); chemistry of carbon and organic substances in sea water (B. A. Skopintsev, Ye. A. Romankevich, O. K. Bordovskiy); extraction of valuable elements from sea water (P. D. Novikov).

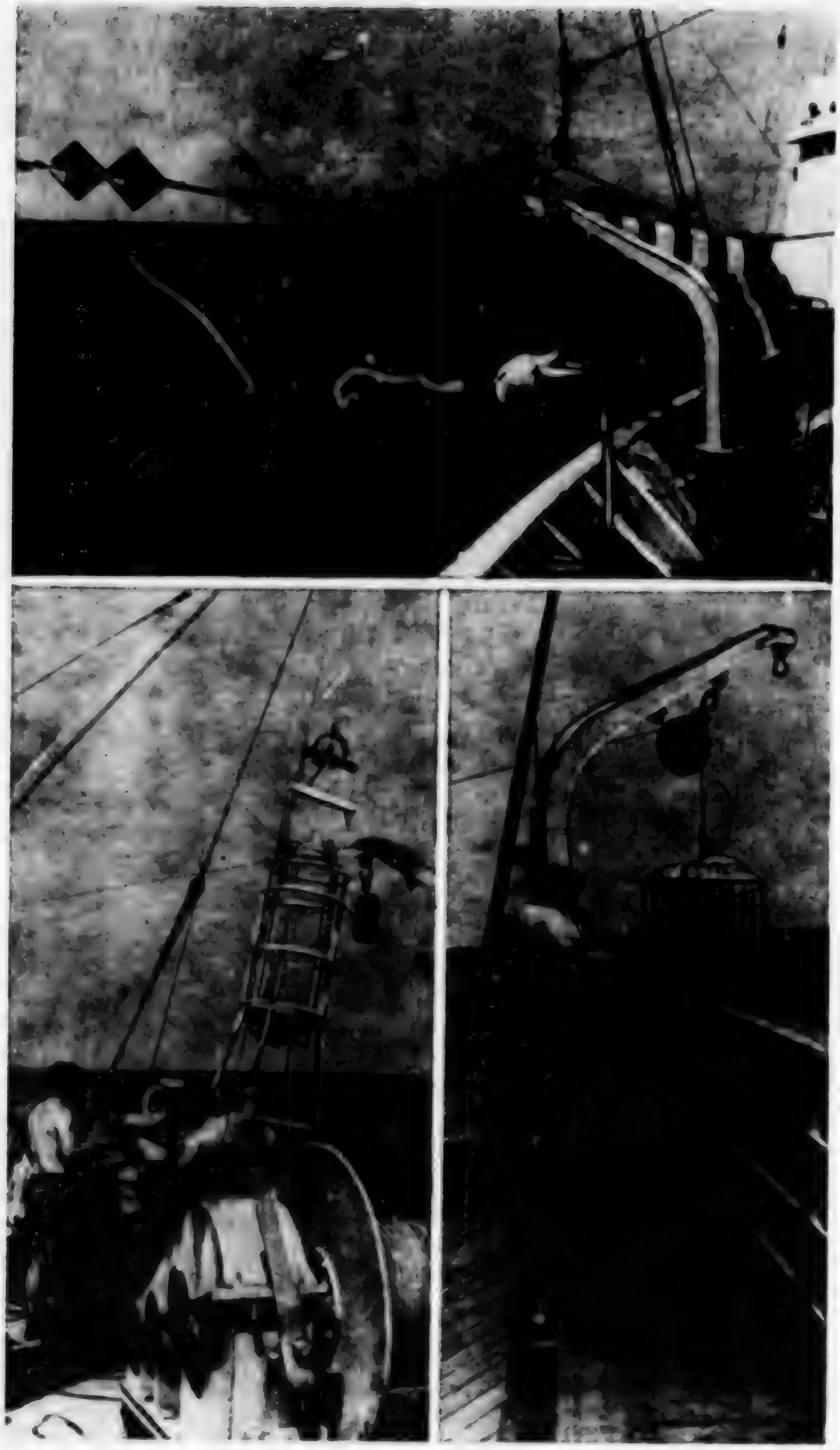

Fig. 1. Work on sea expeditions: at top -- lowering of automatic buoy station from aboard "Akademik Kurchatov" (hydrodynamic experiment "Poligon-70" in tropical Atlantic in 1970); bottom left -- lowering of 150-liter biological bathometer; bottom right -- hydrophysical probe-bathometer (34th voyage of "Akademik Kurchatov" in January 1982). Photograph by K. N. Fedorov.

One of the most productive concepts of marine hydrochemistry is the concept of chemical structure and the principles of chemical-oceanographic regionalization based on this concept. Specialists of the Institute of Oceanology, USSR Academy of Sciences, have carried out work on the chemical-oceanographic regionalization of the world ocean in area and in depth and have constructed hydrochemical maps for 10 horizons from 0 to 5000 m. For example: for oxygen, nitrates, phosphates, silicon.

The experience of the 60-years of development of oceanology in the USSR demonstrated that such a complex object of investigation as the world ocean requires not only diversified knowledge from scientists, but also many specific skills. Among these the most important are the skills of seaman and expeditionary worker. One feature is characteristic of outstanding Soviet ocean specialists. This is the ability to see the world ocean as an integral whole, as a complex natural object in which all the natural internal processes and external effects on it are closely related to one another. A valuable quality of the oceanologist is also the ability to unravel this intertwining of interrelationships and mutual interdependences and finding precisely those links which promise a substantial advance immediately in several directions. Many Soviet oceanologists today have all these qualities and are successfully passing them on to the young generation of researchers.

Today's successes of Soviet oceanology contain the seeds of future progress. In the future as well Soviet scientists will develop scientific investigations of the ocean, as before basing their work on a profound understanding of the inseparable relationship between various processes transpiring in the hydrosphere and their active interaction with atmospheric processes. Much attention must be devoted to the results of human activity -- different anthropogenic changes occurring in the ocean medium. To an ever-increasing degree the investigations of the ocean will be directed to solution of problems determined by practical needs, such as the need for ensuring safe navigation, broadening the fishing industry in the open ocean and developing aquaculture in coastal waters, developing underwater deposits of petroleum, gas and other minerals (for example, manganese nodules), etc. Our administrative agencies rightfully expect from professional oceanologists answers to the question of what must be done in order for the ocean to remain pure, despite its intensive industrial use; what must be done in order that the food resources of the ocean not only be used by mankind, but also be renewed on a scientific basis in a proportion corresponding to the increase in consumption; what must be done, finally, in order to be able to make a scientific prediction of climate change, and even more, prevent their harmful consequences for agriculture, industry and transportation. Soviet oceanologists even now are actively participating in the solution of these and many other problems brought to the forefront by the national economy.

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FIRST VOYAGE OF THE NEW 'VITYAZ''

Moscow ZEMLYA I VSELENNAYA in Russian No 6, Nov-Dec 82 pp 60-64

[Article by V. S. Yastrebov, doctor of technical sciences]

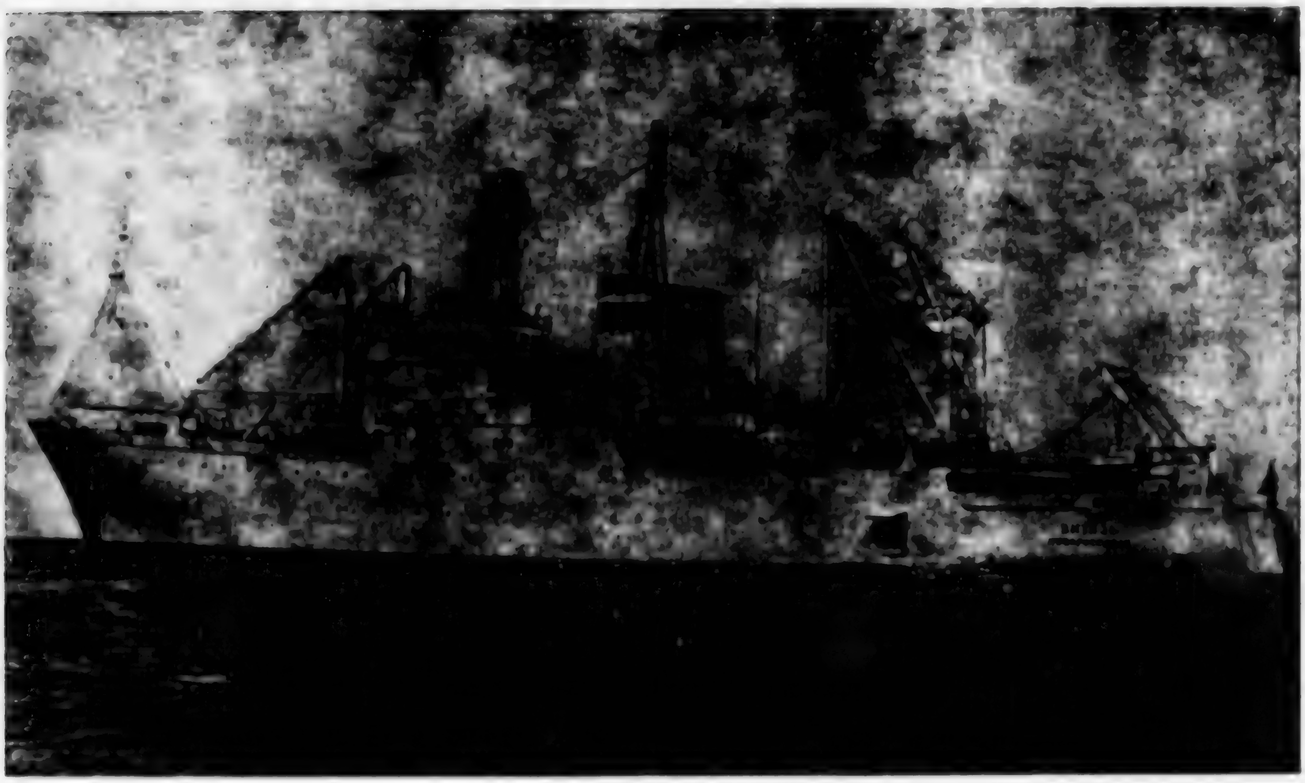
[Text] The national flag was raised on the new scientific research ship of the USSR Academy of Sciences, the "Vityaz'," in December 1981 (ZEMLYA I VSELENNAYA, No 3, p 42, 1982 -- Editor). This indeed is the fourth generation of the "Vityaz'" ships (the famed explorer N. N. Miklukho-Maklay sailed on the first, the Russian scientist and admiral S. O. Makarov sailed on the second, and the third, after its 30 years of service was recently set at permanent anchor at Kaliningrad (ZEMLYA I VSELENNAYA, No 4, pp 58-62, 1980 -- Editor). The new scientific ship, constructed for the Institute of Oceanology, USSR Academy of Sciences, and outfitted with research winches with a hydraulic drive and other modern special equipment and apparatus, a computation center and different laboratories, is intended for carrying out multisided work in the ocean.

On 25 January 1982 the "Vityaz'" left Kaliningrad and headed for the Atlantic. This first voyage was essentially of a shakedown character during which specialists tested the latest apparatus for work at sea. Using this apparatus it was proposed that a detailed geological-geomorphological investigation be made of the shelf zone of Cyprus in the Mediterranean Sea and Ampere Seamount in the Atlantic. Scientists of the Institute of Oceanology, USSR Academy of Sciences, and several specialists of the Institute of Marine Research and Oceanology, Bulgarian Academy of Sciences, participated in the expedition.

A special feature of the technical outfitting of the new "Vityaz'" is an abyssal diving complex which enables divers to submerge to 250 m. It is situated in the ship's prow and includes a hyperbaric chamber with three sections for divers, a diving bell for their transport to deep layers, a life support system and rooms for the storage of cylinders with helium, oxygen, nitrogen and breathing mixture. Also aboard were the manned underwater vehicle "Argus" with a "working depth" of 600 m and the towed vehicle "Zvuk-4," which can carry out an acoustic survey and photographic survey of great areas of the bottom at a depth as great as 4000 m.

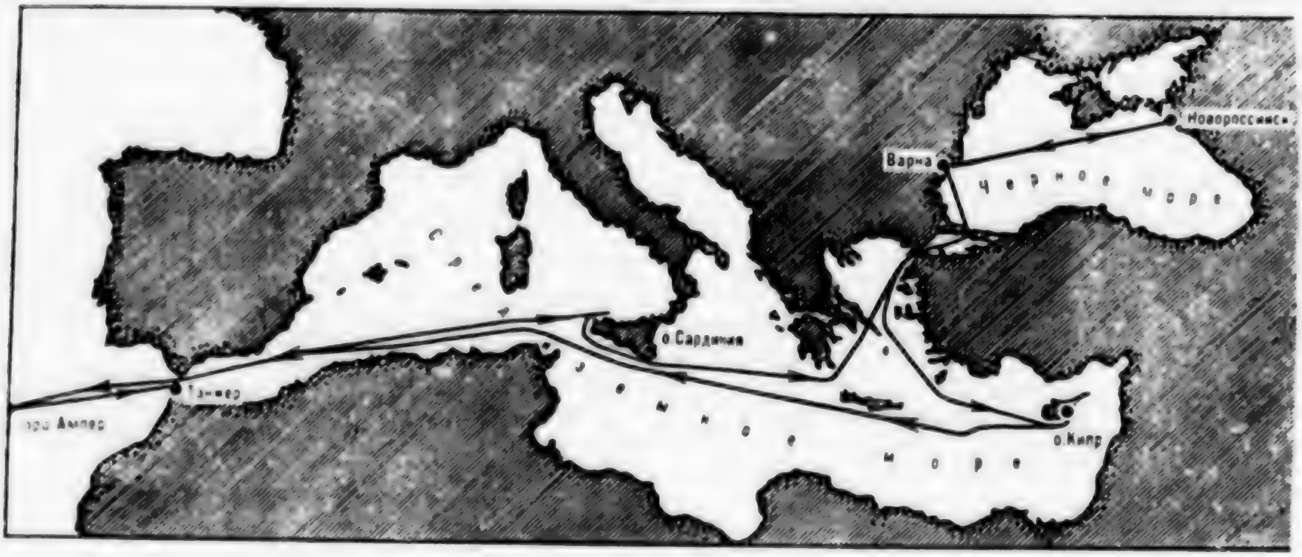
Work Near Cyprus

The choice of the polygons for carrying out underwater investigations was dictated by the scientific interests of the expedition. The island of Cyprus in geological respects is a unique region on the earth. Its central part is the Troodos mountain complex, one of the rare places where it is possible to observe surface outcrops of ophiolites. These rocks, relicts of the ancient oceanic crust, were already formed in the Mesozoic in the process of development of the ancient ocean Thetis. The Mediterranean Sea developed later with the convergence of the African and Eurasian lithospheric plates in the area of Thetis. The Thetis ocean area was for the most part annihilated, with retention of only a small part of it, including the Troodos complex.



New scientific research ship belonging to the fourth generation of vessels assigned the name "Vityaz'".

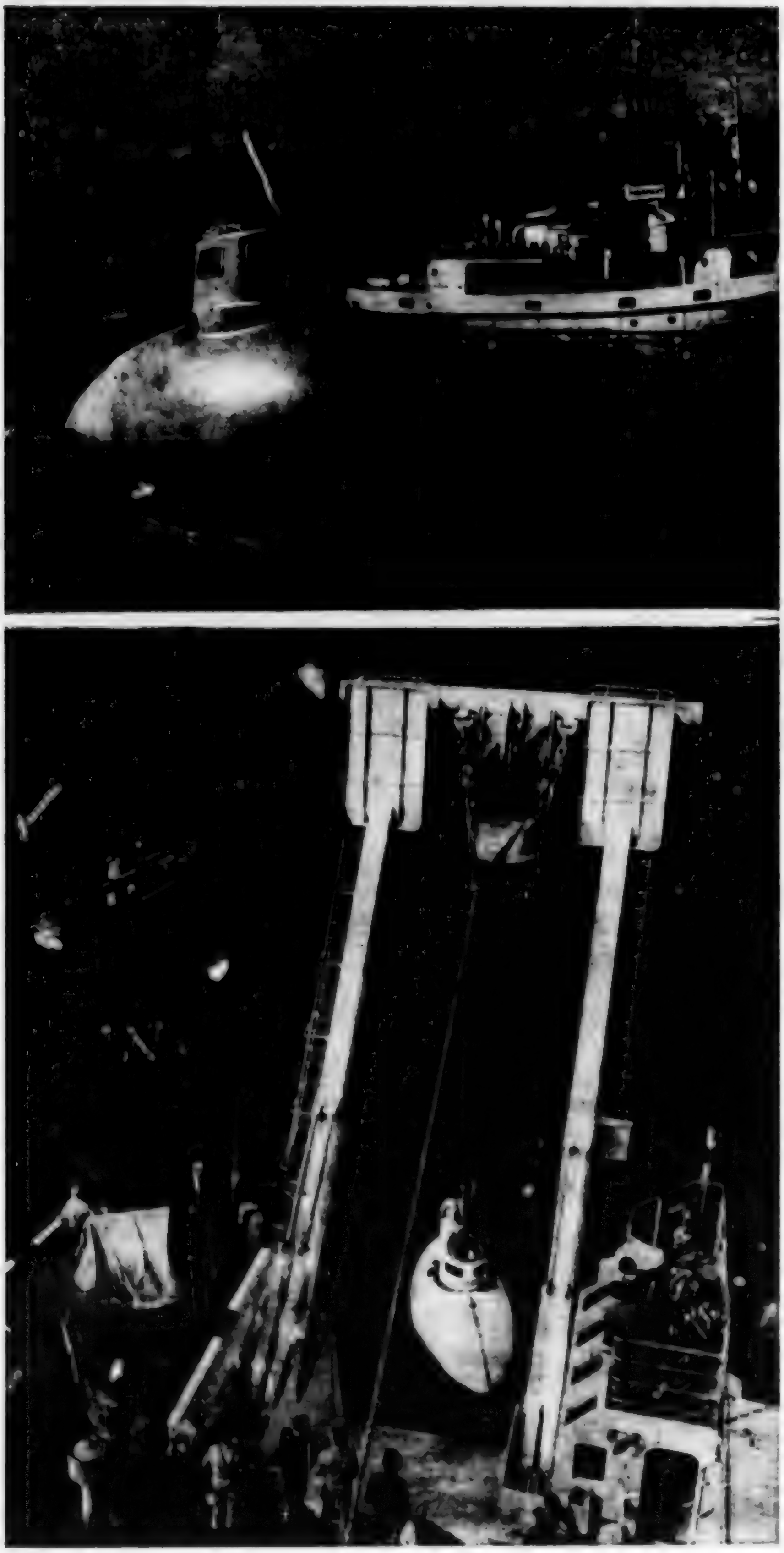
This complex is evidently a remnant of an ancient rift zone, as is indicated by the numerous dikes which are encountered at great distances from the complex. Paleomagnetic data indicate that the axis of the spreading of the bottom was initially situated here to the north and the dikes were oriented in a sublatitudinal direction; later Troodos was turned by 90°. According to the opinion which now prevails, the Troodos ophiolitic complex is a plate of the oceanic crust with a thickness of about 11 km which advanced on the African plate. However, there is also another opinion: Troodos, being an ancient zone of spreading, always belonged to the rift zone and did not change its position relative to it.



Track of voyage.

Surface geological and geophysical investigations of Cyprus have been made in exceptional detail in the past. However, the shelf and abyssal parts of this region have been studied very poorly. For example, it has been unknown how the complex continues underwater and whether its initial position relative to the ancient rift zone remains constant.

The expedition on the "Vityaz'" carried out a detailed geological investigation of the western and northwestern parts of the island shelf. As a result it was found that it is most probable that the Troodos complex goes under water in the northwestern part of the shelf where the ophiolitic complex approaches directly to the shore and the mountain complex is divided. The expedition concentrated its geomorphological investigations in the shelf zone of Khrysokhou Bay, at Cape Akamas. In this polygon specialists carried out echo sounding measurements making it possible to construct a refined map of bottom relief. In areas of the surmised underwater extension of the Troodos complex and the outcropping of bedrock specialists carried out towing of the underwater telecontrolled vehicle "Zvuk-4," by means of which it was possible to obtain images from a two-directional side-scanning sonar and acoustic profilograph and on the basis of these clarify the structure of the sedimentary bottom cover. Interpretation of the records indicated that on the outer (western) side of Cape Akamas and on its inner side the Troodos complex continues underwater and in some places the bedrock emerges at the bottom surface.



"Argus" underwater vehicle and its lowering into water (bottom).

"Argus" Dives

In the course of the expedition a region was selected where it was feasible to continue detailed investigations of the bottom from the "Argus" underwater vehicle. By the beginning of the voyage the "Argus" underwater vehicle had made a total of 150 dives in the Black Sea. Its crew of three persons made many scientific investigations, studying biological and geological problems, improving the method for applying the apparatus. A number of dives were made at the limiting depth for the "Argus" -- 600 meters. And now it was time for the first dives of the underwater vehicle from aboard the scientific research ship "Vityaz'."

Three times the "Argus" made dives on the eastern side of Cape Akamas where there are passages within Khrysokhou Bay, and four more times on the western side of the cape.

Investigations of the eastern part of the cape from the "Argus" were made by three observers. The tracks were laid out in such a way that it was possible to make a detailed investigation of the nature of the underwater ridges at a depth of 450 and 100 m and seek outcrops of bedrock while moving along the axis of the ridge. As a result, in the studied region it was possible to discover two underwater ridges with a meridional strike covered with a layer of sediment. But evidences of the outcropping of bedrocks at the surface were not discovered.

Four observers made detailed geomorphological investigations in the western part of Cape Akamas. Here a ridge extending farther from the shore crossed the track of the "Argus." In addition, the observers discovered an underwater terrace with exposures of bedrock with a height from 5 to 8 m. The terrace extends along the shore at a depth of 150-160 m. The relief of the investigated ridges is variable: in the abyssal part there are sectors with a slope steepness up to 70°, undergoing transition into "saddles." In this region no bedrock outcrops were discovered. With respect to the form of bedding and geomorphological criteria the terrace consists of basalts which unquestionably serve as an underwater continuation of the basalts of the Troodos complex. True, in comparison with the surface basalts the underwater basalts are less weathered and have not been subjected so strongly to different modifications. Here and there on the terrace there were also some formations of the roche moutonnée type. The sea level in this region, judging from observations, was below the present-day level by approximately 100 m.

In addition to geological work on the shelf of the island of Cyprus, in the western and northwestern regions of the shelf the expedition made biological observations. Interesting data were obtained here. In the deep part from 100 to 450 m the bottom was covered by sediment and on the floor there there are a great many openings which are arranged in groups. Alongside these there are conical formations of a regular configuration with a diameter of 100-150 mm with a height up to 100 mm with a slightly concave area at the peak. Taking apart one such cone, the aquanaut discovered there an animal of the Polychaeta type with a length of about 15 cm and a thickness of 2 cm, covered with villi. The animal was not very mobile. The aquanaut believes that it lives in this cone and probably was responsible for its construction. And the aquanauts saw still another interesting animal. Externally it resembled a hedgehog, having soft thin feelers and long tentacles. When the animal vanishes into the opening the tentacles are folded together into a bundle, changing the configuration and size of the body. The aquanauts were able to extract still another inhabitant from the opening -- a sea pen.

Cape Paphos and Ampere Seamount

The expedition on the "Vityaz'" carried out interesting archeological investigations. In the neighborhood of Cape Paphos the divers and hydronauts studied three regions and in two discovered amphorae and other clay articles from ships which in the past experienced shipwreck here. On the sea floor in the neighborhood of Orphurus Island (to the north of Cape Paphos) at a depth from 3 to 12 m the investigators also found remnants of broken amphorae, clay dishes and lamps. One of the groups of archeological finds occupied an area of 50 m^2 on the bottom. Judging from the finds, several ships sank in the Orphurus area. Among the remnants of amphorae, rock outcrops and fissures the aquanauts discovered petrified remnants of wooden frames without any traces of nails, indicative of their deep antiquity. Near Orphurus the expedition investigated an area of the bottom with a total area of about 4000 m^2.

To the southeast of Cape Paphos, near Muliya Island, remnants of amphorae were also discovered, but here there were far fewer. Orphurus Island and Muliya Island are only 50-80 m from the shore and ancient navigators endeavored to use the passage between them and the shore. But during the time of the gales the ships struck underwater rocks and sank in these straits together with their cargo. Finds in the region of Orphurus Island, judging from the age of the amphorae, date back to the 6th-5th centuries B.C.

The second stage in the archeological investigations was carried out on the Ampere Seamount in the eastern Atlantic. It belongs to the systems of underwater volcanoes of the Azores-Gibraltar sill, which evidently developed during the interaction of large lithospheric plates along the boundary of the zones of shear displacements. A knowledge of the age of such volcanoes is important for understanding the geodynamics of the principal types of boundaries of the lithospheric plates. A serious role here is played by a petrological investigation of the rocks raised by volcanic activity from great depths. All this can clarify the nature of the processes which act on the boundary of the mantle and the earth's crust and lead to powerful tectonic movements.

Ampere Seamount is also interesting from the archeological point of view. The fact is that the photographic and television observations carried out here earlier revealed extremely curious rectangular morphostructures on its peak. Archaeologists studying the photographs taken from aboard the scientific research ship "Moskovskiy Universitet" in 1976 and from aboard the "Akademik Kurchatov" in 1979-1980 even postulated an artificial origin of these structures. Divided into blocks by even seams, in the opinion of scientists they resemble the remnants of an ancient stone brickwork. Here the expedition carried out towing of the underwater vehicle "Zvuk-4" for a detailed study of relief of the seamount peak. Such studies pursued a dual purpose. First of all, they made it possible to understand the structure of the entire peak, and second, detailed depth measurements were made and an acoustic survey with photographing of the bottom helped in precisely selecting the place where the diving bell should submerge. In actuality, an error in the place of its submergence can make the latter entirely useless. The planned bottom region becomes completely inaccessible for the aquanauts because the hoses connecting the aquanaut to the bell are only 30 m in length. In this case, however, the ship is at anchor and cannot move.

As a result it was finally possible to select the most interesting point where there was a concentration of numerous outcrops of ridge-walls. The diving bell went down at this point with a crew of aquanauts consisting of Yu. Dulskiy (Marine Research Institute, Bulgarian Academy of Sciences), N. S. Rezinkov and V. A. Antipov (Institute of Oceanology, USSR Academy of Sciences). The bell submerged to 75 m and hovered 10 m from the bottom. After equalization of pressure and opening the hatch the aquanaut N. S. Rezinkov emerged from the bell onto the lower platform, then left the platform and proceeded to implementation of the scientific program.

In submerging the bell was between two walls departing from the plateau at a right angle. To the right and left of them and parallel to them there were ridge-walls of approximately 300 m width, separated from one another by a distance of several meters. At the top the ridges of the walls were incised by linear furrows, lightly sprinkled with a fine white sediment. The aquanaut pushed the sediment away with his hand, finding a deepening in which there was no longer any clear evidence of seams or fissures...

As indicated by the aquanauts, and also by photographs taken in the depths, the entire surface of Ampere Seamount consisted of basalts of a dark color which were greatly smoothed and which virtually nowhere had sharp corners and edges. Evidently, this is a result of the effect of either surface waves in the past or currents which constantly exist in this region. There were no individual rock blocks. Only in one place did the aquanaut discover a small slit and knocked a piece of rock from its edge. The ridge was monolithic -- it had virtually no fissures or scarps.

It was found that Ampere Seamount has a complex dissected relief and its main area is at a depth of 75-85 m. In the northwestern part of the peak there is a hill. Here the thickness of the water layer is 60 m. The ridges-walls, resembling artificial structures, were concentrated in the southeastern part of the peak. These in actuality were rectangular formations rising approximately 6 m above the surface. They run parallel to one another with some interval and frequently intersect -- in some cases at a right angle. In the overwhelming majority of cases the walls have a block structure, which suggests their artificial origin. The blocks are sometimes clearly separated by fissures. The mountain surface, both at the foot of the ridges and at the peak, is covered by small recesses strewn with a thin layer of sediment. This suggests that slit-joints exist beneath them. The deepenings cut the surface of the blocks primarily into rectangles. Sometimes the system of such rectangles has a linear strike; in other cases they form semicircles ("arches") of a regular configuration.

At the peak of Ampere Seamount the aquanauts discovered steep and smaller walls with a height up to 1 m, also of a rectangular configuration. When the mountain peak was photographed earlier an image was obtained only of these small walls because the survey was made from a distance of 2-3 m, so that the large ridge-walls entered the frame only as individual fragments or as a general background. The major ridges could be interpreted on the records of the side-scanning sonar after investigation of the bottom by aquanauts.

What did the detailed investigations of Ampere Seamount give on the first voyage of the "Vityaz'"? They indicated that this mountain has a volcanic origin and its peak consisted of alkaline basalts. The peak earlier protruded above the ocean surface, as is confirmed by the large block structure of the outpouring lavas, which would be substantially different if the outpouring occurred under water. A sample of basalt raised from the seamount peak was extremely porous in cleavage, also evidence against an underwater outflowing.

For the time being it can be said that the investigations have not confirmed an artificial origin of the basalt ridge-walls. True, over an enormous time interval artificial structures could change so much outwardly that now they cannot really be distinguished from the general natural background of the peak. Accordingly, it is probably too early to draw final conclusions.

Much was done during the time of the first "Vityaz'" expedition, which lasted for two months. I would particularly like to note that the method for multisided underwater research developed at the Institute of Oceanology, USSR Academy of Sciences, in these 15 years has fully justified itself. The scientific results of the expedition indicated how productively it is possible to carry out investigations of the world ocean using the facilities of the scientific research ship "Vityaz'."

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FLT ADM S. GORSHKOV ON STUDY, USES OF OCEANS

Moscow MORSKOY SBORNIK in Russian No 12, Dec 82 (signed to press 14 Dec 82) pp 16-26

[Article by CinC Navy Flt Adm SU S. Gorshkov: "Contemporary Problems of the Study and Development of the Ocean"; passages rendered in all capital letters printed in boldface in source]

[Text] The study and development of the ocean under present-day conditions is gaining special importance in connection with the people's ever-increasing dependence on its resources. Significantly increased technical capabilities in recent years allowed a sharp increase in the intensity of research. These were the circumstances which led to the UN General Assembly declaring the period from 1971 through 1980 an oceanologic decade.

Two directions can be discerned in the approach to problems of the ocean's study and development. The first direction, involving an expansion in opportunities for the joint use of its resources for increasing mankind's welfare, was advanced by the Soviet Union, countries of the socialist community and many developing states. The second direction is typical of the leading capitalist countries headed by the United States. It has the purpose of using the ocean for militaristic interests as a sphere of economic expansion and for establishment of their domination here, and to open up as it were a new era of colonial conquests, this time not on land, but in the ocean depths.

The world community cannot reconcile itself with such aspirations of the imperialist powers.

For a long while the overwhelming majority of world states[1] have been connected with opportunities for use of ocean resources and profitable shipping lanes crossing it. That is how the first aspect of the problem, which can be termed the "man-ocean" problem, originated and has been developing continuously: the ECONOMIC aspect.

At the same time people were using the oceans and seas as springboards for conducting military actions. These capabilities rose as productive forces developed. The present-day operational-strategic features of ocean-going nuclear missile fleets have reached a pinnacle at the present time. That is how the second aspect of the very same problem--the MILITARY aspect--arose and has been developing continuously. Both these aspects exist objectively in close unity, and their importance is growing continuously.

The ocean occupies more than 70 percent of the surface of the globe. With a colossal volume of water exceeding 1.3 billion cubic kilometers, i.e., 97.3 percent of all our planet's water reserves, it exerts an enormous effect on the physical condition of continents and the earth's atmosphere. The great spatial and temporal changeability of basic physical and chemical characteristics of ocean waters affects the processes of vital activities of living organisms which take place in it.

The ocean waters are in constant movement. Their movements, which form a general system of currents, serve as the basis for uniformity of the ocean's nature. Subtropical circulations, which include for example such powerful currents as the Gulf Stream and Kuroshio, represent some of the chief elements of this system.

Diverse physical processes occur in ocean waters. A global transformation of metabolic energy occurs here as a result of the uneven heating of waters and the atmosphere. The ocean absorbs three-fourths of solar radiation which the earth receives, thus maintaining the temperature conditions of water masses and the air masses above them, and it regulates the entire cycle of planetary atmospheric and oceanic circulation. It has an effect on formation of the climate of all regions of our planet. Any sector of land, even one farthest from the sea, inevitably experiences its influence. All this still is far from understood and is the subject of careful study by researchers and scientists, seafarers and oceanographers.

The ocean's fauna and flora are unusually varied, numbering more than 160,000 species of fauna and some 10,000 species of flora. The life of some 250-260 species of birds is linked with the ocean. The ocean represents the lungs of the globe. Around half of the oxygen entering the atmosphere is produced in the process of photosynthesis by phytoplankton in the ocean.

We still have a very poor knowledge of the ocean world although as far back as deep antiquity (4,000-5,000 years ago) man learned to use the sea lanes for communication with island areas and even made ocean voyages on primitive (in modern terms) cane and board raft vessels. The well-known Norwegian scientist-oceanologist and sea traveler Thor Heyerdahl tells about this very persuasively in his book entitled "Early Man and the Ocean," published in the Soviet Union in 1982.

But the study of the ocean as an object of scientific understanding of the planet began considerably later, some 250 years ago, and its systematic study has been conducted for a little over 100 years. Nevertheless even today we know very little about the ocean world and about all the processes occurring in its depths.

Thanks to scientific-technical progress, attention to the ocean was reinforced following World War II. Marine science studies began to be organized on broad scales both by individual countries and within the framework of coordinated international programs. The scope of the work of basic research of the ocean, as well as for interests of the armed forces, increases each year. For example, in 1966, in elaborating a 5-10 year program for study of the ocean, the Department of Oceanography of the U.S. Presidential Scientific Consultative Committee defined its primary direction as support of national defense. In fact when we turn to data on U.S. federal appropriations allocated for the study and development of the ocean, such as in 1975, it can be noted that some third of the entire amount ($244 million) of $782.5 million went to the Defense Department. Various federal departments, universities and science centers are widely enlisted to perform this work. At the same time the federal budget does not take account of U.S. Navy expenditures for oceanographic research to support the activities of submarines and ASW forces and means. According to some American sources,[2] in that same year of 1975 this comprised a rather impressive amount--at least $550 million. Oceanographic research directed at a study of features of sound propagation under the water in various parts of the ocean, acoustic characteristics of water masses and soils, as well as work of hydrographic and geodetic survey and on ocean biology represent special interest to the Pentagon. To this end floating and underwater facilities which can affect the freedom of navigation and scientific research are being set up for this purpose in vast expanses of the ocean. This predetermines the appearance of one other aspect of the "man-ocean" problem--POLITICAL-LEGAL.

In recent decades there has been a reinforced trend toward a more ordered legal regulation of all kinds of ocean uses. The 3d UN Law of the Sea Conference lasted some 10 years. Here the delegations from practically all countries in the world worked out a international legal document defining the all-encompassing legal regime for marine expanses. In all phases of the Conference the USSR delegation consistently advocated a most rapid development of a new Law of the Sea Convention on a compromise basis which would be a significant contribution toward strengthening international security and would help prevent conflicts among states on the seas. To facilitate progress in the Conference's work and considering the interests of developing countries, the Soviet Union accepted a number of concessions (recognition of the concept of a 200-nautical mile economic zone, the permissive procedure of scientific research in the economic zone and on the continental shelf, and so on).

The leading capitalist states, and the United States above all, took a different approach to resolving the global problem facing the Conference. Their desire for undivided rule on the ocean expanses was manifested most vividly in the adoption, at U.S. initiative, of national laws on development of deep-water seabed resources. Using this legislation and the related threat of substituting a system of "minitreaties" for the Convention as a blackmail tool, the American administration placed the Conference on the verge of disruption and delayed adoption of a new Convention for a year. But the demands of the United States and its other NATO allies to recarve provisions of this document concerning exploration and development of seabed resources beyond shelf limits in their favor--demands which were utterly unsubstantiated--ended in total failure. At the 11th Session of the Conference held on 30 April 1982 a Law of the Sea Convention was adopted and the process of signing it began in December 1982.

Questions of an intensification of scientific studies of the ocean are more acute in this connection. Back in the middle of this century a need arose, under the influence of objective needs of oceanographic science, for creating a certain cooperation of states to conduct synchronous studies over considerable areas of the ocean. Several major international programs were developed for studying the tropical Atlantic (1962-1964), the Kuroshio current (1965-1971), the Caribbean Sea (1967), the Northeast and Northwest Atlantic (1973, 1976, 1977), and so on. The Soviet Union is taking an active part in fulfilling the majority of them. An exchange of international information is of great importance for ocean study. Over 70 countries--members of the UNESCO Intergovernmental Oceanographic Commission (MOK)--participate in it. The information exchanged is carried out through world oceanographic data centers located in the USSR and United States. Each year the results of observations from several hundred expeditions carried out in various parts of the ocean arrive in the USSR. The Soviet Union passes on materials of 40-45 voyages of its science research vessels for use by members of the UNESCO MOK.

Soviet scientists are making a substantial contribution to the total sum of knowledge about the ocean. They have to their credit the measurement of the deepest depressions of the Pacific Ocean, and the discovery and study of an underwater sound channel, submarine ridges in the Atlantic and Arctic oceans, the fine structure of hydrophysical fields, synoptic vortices, the dynamics of water masses in the deepest parts of the ocean, life at extreme depths and so on.

The purpose of oceanographic research at the present stage is to develop and improve prognostic models reflecting conditions of the ocean medium and to perform comprehensive programs for the study of ocean and atmospheric processes and their connection with mesoprocesses and microprocesses which determine the status of weather on all continents. Oceanographic studies are multifaceted (according to the subject criterion of ocean study they can be divided arbitrarily into hydrophysical, hydrochemical, geophysical and biological), but all of them are associated by the overall theme of understanding the ocean. This is determined by the close interrelationship of various kinds of studies. For example, biological studies require a simultaneous study of the physical state of water masses and chemical processes in those areas in which living organisms are being studied, and a knowledge of chemical processes is necessary for constructing a hydrodynamic model of the ocean.

Primary efforts in the area of hydrophysical studies are directed at creating and improving a thermodynamic model of the ocean and developing a unified model of circulation of the ocean's water masses and the atmosphere above it. This will permit describing dynamic processes in the ocean from the microscale processes to planetary processes with consideration of their mutual influence. The study of microprocesses is being given much attention of late, since without a knowledge of their mechanisms it is impossible to obtain a valid picture of planetary-level fields and create prognostic models.

Studies of ocean acoustics play no small part. This is determined on the one hand by the importance of a practical use of sound waves for detecting objects under the water, and on the other hand by rapid receipt of information about the status of bottom relief.

An important place in hydrophysical research is held by the study of ocean optics--optical fields, conditions of their formation and interrelationship with other fields--and a determination of primary and secondary hydro-optic characteristics, principles of light propagation in an aqueous medium, and optical properties and conditions of the ocean surface.

Hydrochemical research is a rapidly developing direction in ocean study. Of particular interest here are phenomena occurring at the interfaces of water masses with the atmosphere, the bottom and the coastline and which are called upon to play an important part in the development of prognostic models thanks to establishment of the nature of chemical processes.

Geophysical research encompasses the study of spatial-temporal characteristics of the magnetic and gravitational fields in the ocean, properties of the ocean bed and thickness of the crust beneath it.

The basic task of biological research is a study of the vital activities of varied species of marine animals, plants and entire ecological systems. Scientists are attempting to obtain an answer to the question of how a change in climate affects ecosystems and understand the mechanisms regulating their structure and interaction.

Oceanographic research vessels (OIS) of the Ministry of Defense Main Directorate of Navigation and Oceanography (GUNiO MO) make a great contribution toward accomplishing ocean study tasks in the interests of the national economy and marine sciences, along with the scientific research vessels of the USSR Academy of Sciences and vessels of the USSR State Committee for Hydrometeorology and Environmental Control. They take part in the fulfillment of many international and practically all national programs for ocean study.

Vessels of the Navy's Hydrographic Service "Admiral Vladimirskiy" and "Faddey Bellinsgauzen" left Sevastopol' on 2 December 1982 on an around-the-world Antarctic expedition following the route of the great Russian seafarers F. Bellingsgauzen and M. Lazarev, and they will perform extensive scientific studies.

The studies being performed have not only an applied character, but a basic scientific character as well. The use of modern equipment for ocean study including electronic computers with an automatic oceanographic data collection and processing system and sounding bottles allows the Navy's OIS to measure a considerable number of parameters of oceanographic fields simultaneously in various scales of their manifestation.

Study results will augment the Soviet national store of materials of hydrometeorological, hydrographic, geophysical and hydrobiological observations in the ocean. They are the basis for compilation of various aids, sailing directions, sailing manuals and atlases needed for naval ships, general navigation and for science of the ocean in general.

Soviet marine charts supporting navigation in practically all parts of the world have been published based on materials of Soviet hydrographic studies in the oceans and seas and with the use of foreign cartographic sources. The

Soviet "World Ocean" chart published by GUNiO MO in 1979 contains the latest seabed relief data and is one of the best in the world.

There was a significant expansion in the products list of equipment for performing studies as the extent of knowledge about the ocean grew and as demands for its study increased. Numerous scientific establishments, firms and concerns in many countries are working on its development.

Automated systems are being installed aboard oceanographic scientific research vessels which have been made on the basis of EVM [electronic computers] and which provide for the collection, analysis and processing of oceanographic data, the monitoring of measurement errors, their tie-in with navigational measurements, recording on a machine-readable medium and reproduction in a graphic form. A set of equipment including precision and quick-response meters for all physical characteristics of the ocean medium and various fields of the planet is being used to determine oceanographic parameters. Further development of oceanographic systems apparently will follow the line of supporting full automation of the research process.

The use of submersible vehicles for various purposes is something new in the study of oceans and seas. Scientists' efforts are aimed at increasing their submersion depths, creating conditions for conducting scientific studies and increasing the safety of aquanauts.

Automatic anchored and drifting research buoys and self-contained hydrometeostations have become widespread of late. They can be used to measure several dozen hydrometerological parameters and transmit them to shore centers over a radio channel or via artificial earth satellites. The use of automatic buoys permits setting up systems for rapid coverage of the hydrometerological situation over vast ocean areas.

Great prospects for oceanographic studies opened up with the beginning of the use of specialized earth satellites. Outfitted with television, infrared and radiometric gear, they send information to earth about cloud cover above the ocean, the ice cover, temperature of the surface layer of water, wind at the water's surface, and sea states. Flying around the globe in a time enormously less than the natural changeability of the marine and air medium, such satellites are capable of providing a global picture of the distribution of many important oceanographic parameters.

A number of the most important scientific-technical problems connected with study of the biological structure of the ocean medium and the upper mantle of the earth's crust, with the performance of hydrologic and hydrographic studies, and with the performance of rescue operations, salvage operations and other underwater engineering work cannot be resolved without man's active penetration into the ocean depths. This gave birth to a new direction in the theory and practice of human medicine and physiology, which studies conditions of the body's behavior under the extreme conditions of the hydrosphere. People have penetrated to a depth of 200-300 m relying on the latest scientific achievements. In the future this may be taken to 500 m or more. This requires the creation of more sophisticated special gear supporting human life and activity in the underwater medium.

Thus the problem of human vital activities at great depths is a new independent area of medical and physiological research, the success of which will determine accomplishment of tasks of developing the ocean.

As was noted earlier, there are enormous raw material, biological and energy resources in the planet's hydrosphere. People will turn their gaze more and more toward the ocean as opportunities for producing everything necessary for their existence from the interior and surface of the land are exhausted. "In the near future," affirms well-known Soviet scientist S. Mikhaylov, "the land will not be in a condition to satisfy mankind's growing needs for metals, minerals, petroleum and coal as well as for chemical raw materials and proteins of animal origin. The ocean is the first extracontinental source for satisfying people's needs for food, chemicals, fuel-energy and mineral-raw material resources . . . and hence it is natural that there is a present interest in this matter."[3]

Mankind is striving for more complete use of ocean resources, as manifested not only in an intensification of scientific research, but also in a growth of appropriations for its economic development. Over the last 20 years, for example, world capital investments in basic sectors of the marine economy have increased almost tenfold and in 1975 reached the vast sum of $120 billion including $60-70 billion for the sea mining industry, $10 billion for the fishing industry and $40 billion for shipping.[4]

Economic development of the ocean began with the use of its biological resources, which play an increasingly noticeable role in the food balance of our planet's population. Scientists believe that the ocean's potential biological reserves exceed those on land by many times over. Even today it "supplies" us with up to 15 percent of proteins and 5 percent of fats of animal origin in worldwide consumption.[5] The world catch of fish and other sea products comprises some 70 million tons annually,[6] and this index may be increased in the near future.

The competitive struggle which unfolded in fishing and other fisheries (which is so typical of the capitalist system of economic operation) often assumes interstate scales and at times complicates relations even among allies in one and the same blocs. Suffice it to recall in this regard the recent so-called "wars": the "cod" war between Iceland and Great Britain, the "lobster war" between France and Brazil and the "tuna war" between the United States and Mexico. Acting on the one hand were countries with insufficient economic and military might and, on the other hand, great sea powers which often used combatants of their navies as a "convincing" argument for resolving the dispute.

According to scientists' prognoses, there are more mineral and chemical resources in the ocean than on land. Sea water itself is a valuable "polymineral liquid ore" which contains more than 70 elements of the Mendeleyev Table. The total reserves of some of them reach astronomic proportions. There are billions of tons of manganese, iodine, bromine, vanadium, magnesium, potassium and calcium, and millions of tons of gold, silver, thorium and other rare elements. Reserves of uranium (4-5 billion tons) and heavy water (over 270 trillion tons) can have very great importance for technical progress in the future.[7]

Very rich deposits of iron and manganese (polymetallic) nodules[8] containing manganese (25 percent), iron (14 percent) as well as cobalt, nickel, copper, titanium and vanadium have been discovered over vast areas of the Atlantic, Indian and Pacific ocean seabed. The depths of the seabed contain enormous stores of petroleum and natural gas, especially in continental shelf areas.[9]

In 1975, for example, the reserves of marine petroleum comprised 21 billion tons and those of natural gas, 14 trillion cubic meters.[10]

In addition to petroleum and natural gas, the shelf contains deposits of coal and ores. Huge deposits of coal have been surveyed near the shores of Great Britain, Japan, Spitsbergen, Chile, Australia, Turkey, China and the United States. There were 57 underwater coal mines in operation in the world as early as the beginning of the 1970's. Japan obtains 30 percent of all coal from the depths of the seabed, and Great Britain gets 10 percent of its coal from there.[11]

Today the industrially developed countries are conducting intensive scientific research and development work to create special equipment for the production of minerals in deep-sea areas.

The heightened interest of capitalist countries in the ocean is caused by the fact that some 70 percent of minerals on land are under the control of socialist and developing countries. The economy of the United States and its chief partners--Great Britain, Japan, the FRG, France and others--depends to an enormous extent on the import of a number of the most important kinds of raw materials. Satisfaction of their constantly growing needs for energy and for mineral and food raw materials depends more and more on the possibilities of developing the ocean's economic resources. For the time being, however, this problem is being solved primarily by importing raw materials obtained on land.

Petroleum and natural gas are of particular importance out of all the kinds of strategic raw materials found in the depths of the sea and ocean bottom. By the mid-1970's the shelf accounted for 20 percent of the total production of petroleum and over 10 percent of natural gas and, according to specialists' forecasts, by 1985 the proportion of petroleum will comprise some half of world production. At the present time more than 20 countries are producing petroleum and natural gas from the seabed, and some 100 countries are conducting exploratory drilling and geological exploration work. There are major petroleum and natural gas deposits in the North Sea, Gulf of Mexico, Persian Gulf and other areas.

In the next few years the exploration and development of seabed mineral resources beyond the continental shelf will gain an exceptional role. It has been established that there are gigantic deposits of metals in nodules and in certain other formations such as sulfides on and under the seabed. According to scientists' estimates the oceans' reserves of raw minerals from which manganese, cobalt, copper, nickel and other metals can be obtained surpass all such resources explored on land by tens and even hundreds of times. While some 20 countries will be able to derive perceptible profits from activity on the continental shelf beyond the 200-nautical mile economic zone, practically all world countries including inland countries will be able to do so with appropriate organization of work on the seabed beyond the shelf.

Beginning in 1967 the United Nations has been making attempts to draw up an appropriate seabed regime beyond the continental shelf. Initially the UN Seabed Committee worked on this, and then the 3d UN Law of the Sea Conference did so beginning in 1973. The new Law of the Sea Convention contains principles regulating the exploration and development of seabed resources beyond the continental shelf. In particular, this area with its resources is declared mankind's general legacy. It is open for use by all states exclusively for peaceful purposes. Work in the area will be carried out by a specially formed international Agency (through its Enterprise) and by countries participating in the Convention and their representatives. This will ensure a just and rational use of seabed resources with consideration of the needs of developing states. Such prospects, however, clearly were not to the taste of the United States and its partners. Despite the fact that their attempts to introduce changes to this part of the Convention which would have secured for them unilateral advantages and preferences suffered failure, they have not rejected their intention to set themselves up in the most promising and rich seabed areas according to the principle of "first come, first served," contrary to the interests of all other countries.

U.S. ambitions have gone so far that President Reagan officially announced refusal to sign the new Law of the Sea Convention adopted in April of this year. His statement that Convention provisions concerning development of seabed resources allegedly "do not correspond to U.S. goals" is absolutely unfounded. The fact is that this is that part of the Convention to which the American delegation, which represented the three previous U.S. administrations, gave greatest attention in its development.

The present administration apparently cannot reconcile itself with the fact that under the Convention ocean resources can be used in the interests of all countries, and developing countries above all. The government of monopolies does not like the fact that the Convention contains rather effective antimonopoly provisions (albeit not rigid ones) in the section devoted to seabed resources and that it does not allow uncontrolled access of private companies to the production of these resources. Moreover, the imperialist monopolies cannot reconcile themselves with the fact that the decisionmaking procedure in the Council of the future International Seabed Agency does not allow the United States to play the very same dominating role in it as in international financial organizations. It should be noted that not one of the states participating in the Law of the Sea Convention ever have been in such isolation as the United States, no matter what proposals it advanced during the work. Not counting Israel, even the closest of its NATO allies did not deem it possible to vote against the Convention. The Canadian government sent Washington a note of protest in connection with the new administration's unilateral rejection of previously reached agreements.

It is quite obvious that the U.S. delay of talks on problems of the ocean and nonrecognition of many provisions regulating the international legal aspects of the "man-ocean" problem previously worked out with its very participation is the result of a policy directed at obtaining additional opportunities guaranteeing the conduct of those activities which are connected with a resolution of the problem of dominance in the ocean.

By its obstructionist policy with regard to the Law of the Sea Conference, the United States sets itself in opposition to the interests of the world community. This is absolutely unacceptable. The "threat" of the present U.S. administration not to sign the Convention must not stop other countries. Adoption of a mandatory international law will permit regulation of relationships of all countries in the development and use of the ocean and regulation of rules for navigation and use of sea expanses.

The seas and oceans already are beginning to be used for the accommodation of various kinds of enterprises in connection with the rapid inclusion of seabed mineral resources in the sphere of economic activity of developed capitalist countries. Some parts of the ocean even now are gaining strategic importance having been turned into areas of heavy industry developed and concentrated in small water areas with enterprises for the mining, storage and processing of raw materials. For example, Great Britain, Norway, the FRG and other countries erected numerous facilities in the North Sea for the production and transportation of petroleum and natural gas. Possibilities are being studied abroad for using manmade islands for construction of industrial enterprises. For example, it was reported in the press that the Japanese are developing a project for creating a manmade island with the construction on it of a metallurgical plant, aluminum plant, oil refinery and petrochemical plant, as well as a large-capacity distilling plant. There will be 20,000-25,000 persons servicing the island. Despite the seeming fantastic nature of such projects, they may become reality in the near future.

Great horizons open up for mankind in connection with the possibility of developing inexhaustible ocean reserves of mechanical, thermal and chemical energy. There is colossal energy potential contained in ocean waves, currents and tides. The use of the oceans' hydrothermal energy, i.e., the energy obtained from the temperature difference at the sea's surface in warm areas (25-30°C) and in the depths (around 5°C), can provide much for mankind.

Other projects for using the energy of oceans are known. The United States, for example, is examining the question of using the heat and flow of the Florida part of the Gulf Stream, which in the American specialists' estimate basically can satisfy the country's energy needs. It is true that for now only scientific explorations of technical solutions are being conducted in these areas. At the present time only the first experimental tidal electric power plants have been created, but significant prospects already are looming for practical development of the ocean's energy potential for mankind's needs.

There are truly inexhaustible capacities contained in the energy found, for example, in ocean reserves of heavy water. It is generally known that one kilogram of heavy water would be able to compensate in energy released for the combustion of 400 tons of coal. When we consider that the ocean has hundreds of trillions of tons of heavy water, it is quite obvious that the discovery of inexpensive methods of recovering such energy from the ocean can lay a path toward solving the energy problem of modern times, which is greatly disturbing mankind and which has drawn the careful attention of the 26th CPSU Congress.[12]

In appraising the acute need for a further build-up of the country's available power, USSR Academy of Sciences President Academician A. Aleksandrov stated: "The traditional methods, i.e., by increasing the production of energy carriers (petroleum, natural gas and coal), will cease to satisfy us in the foreseeable future. There must be a substantial change in the structure of their consumption and wide use of nontraditional energy resources."[13] I would like to add to this that the ocean also can become one of the primary sources of energy used by mankind in the future.

The role of oceans and seas is exceptionally important in supporting transportation ties among continents and countries. The uninterrupted functioning of sea lines of communication is a matter of life and death for a number of industrially developed coastal and especially island states such as Great Britain and Japan. It is not by chance that marine transportation plays a leading role among all kinds of transportation. It accounts for over three-fourths of world freight exchange. This is above all because the production costs of sea shipments is 40-45 percent lower than rail and 20 times less than motor vehicle shipments. The total volume of world ocean and sea shipping is growing continuously. In just the last 20 years it increased more than fourfold, comprising some 3.5 billion tons a year in the mid-1970's.

The Atlantic Ocean holds first place in shipping, accounting for over two-thirds of the world freight turnover. Its basin contains 8 socialist, 23 developed capitalist and 53 developing countries, with all of them accounting for 80 percent of the world industrial production.[14]

More than 20 percent of world freight is shipped over sea lanes of the Pacific and up to 10 percent over those of the Indian Ocean.

Ocean and sea lines of communication are of great economic importance for the Soviet Union. For this reason the Communist Party and Soviet government give constant attention to the development and improvement of our country's sea transportation ties with other states, which requires the performance of major, goal-oriented scientific research involving the creation of charts, sailing directions and aids to navigation, organization of a weather forecasting service, and other measures assuring the most economically profitable organization and management of shipping.

In pointing out the ever growing importance to many countries of marine production of food, raw material and energy resources and the expansion in maritime shipping, the foreign press notes on the one hand their growing economic dependence on the extent of ocean development and on the other hand the appearance of new serious sources of international conflicts. "In the year 2001 we could easily develop mines and agriculture on the seabed and use transportation and military facilities. As soon as we begin to use these new bases of economy, a new arena of conflicts automatically will appear."[15]

Suppositions are even expressed that as manned seabed stations and industrial facilities are created the developed capitalist countries will attempt to establish "underwater spheres of influence."

The waters and bed of the ocean are being turned into an object of struggle and expansion through the efforts of a number of capitalist countries. Evidence of this is the keen struggle of NATO allies--Greece and Turkey--for sources of petroleum discovered under the Aegean Sea. Such situations, and there are many in the modern world, can lead to military conflicts.

The irrepressible thirst of capitalist states to seize more and more areas of the ocean also is manifested in their attempt to invest even small islets lost in the ocean, such as the British rock of Rockall located more than 200 nm from the British Isles, with rights not only to territorial waters, but even a continental shelf and also a 200-nautical mile economic zone. To this same end areas of underwater volcanic activity in the Pacific are under constant U.S. and Japanese observation. The islands appearing here serve as an object of immediate seizure.

And so the rivalry to acquire riches of the hydrosphere and to extend states' influence to vast ocean zones led to a sharp intensification of the struggle among imperialist countries. Man's contemporary level of understanding of the ocean affected the change in methods and forms of armed warfare, and the strategic and operational employment of fleets above all. Through efforts of the imperialist powers the ocean has been transformed into an enormous springboard for conducting combat actions and naval operations by all-arms fleets--submarines, surface combatants and naval aviation. The role of the marine medium has risen unusually in the modern era of acute struggle between two opposite social systems, where imperialism headed by the United States is conducting feverish preparations for a new world war, having placed the most important scientific-technical achievements at the service of this task. The ocean also has become an arena for employment of other branches of the armed forces.

Development of the ocean opens up opportunities for a further spread of military actions from the ocean surface into its depths. Suffice it to note that following World War I submarines increased submerged depth by almost tenfold. Mine ordnance previously employed only in coastal and shallow-water areas now can be used at depths of several thousand meters, according to the western press. American sonar submarine detection systems are located at great depths of the ocean floor.

In viewing the ocean as a springboard for conducting armed warfare and for deploying strategic nuclear-missile groupings of armed forces for these purposes, the United States is carrying out major, costly projects across a broad front to fit it out and prepare it as a theater of military operations.

In summing up what has been said, we will note that the ocean is becoming a more and more important economic factor in the life of many countries and the object of intensifying competition and acute political and potentially armed struggle among them. It is a worldwide storehouse of enormous riches and a source of energy resources, the door to which is still open to all for now, but the imperialist states are trying more and more persistently to gather all ocean resources into their hands. For this reason an understanding of the essence of the problems of its economic development has not only a national economic importance, but a defense importance as well.

The problem of ocean development is inseparable from preservation of peace on the planet. Comrade L. I. Brezhnev emphasized: "Peace is not just a question of security. It is also the most important precondition for resolving the most important problems of modern civilization . . . which even today are beginning to concern many people: resolution of the problem of energy resources, environmental protection, elimination of such phenomena as mass hunger and dangerous diseases, and development of ocean resources."[16]

The new international legal regime of the ocean, the primary provisions of which were secured in the Law of the Sea Convention, is called upon to play a very important role in world use of maritime expanses. The preamble to this document recognizes its great contribution toward establishing a legal regime for seas and oceans which would facilitate international communications, the just and effective use of their resources, and the study, protection and preservation of the marine medium as well as its living resources. The preamble expresses confidence that development of maritime law reached in this Convention will contribute to a strengthening of peace and security of nations and aid their economic and social progress.

The Convention precisely defines the limits and regime of sea expanses (territorial waters, economic zones, continental shelf and so on) and the regime of international straits, archipelago states, the open sea, inland and partially enclosed seas, the seabed beyond the continental shelf and so on. There is a regulation of such very important kinds of human activity in the ocean as shipping, fishing, the development of marine minerals, construction of manmade islands and facilities, and prevention of pollution of the marine medium. A procedure is established for delimiting sea expanses between adjacent states. A system of measures is envisaged for the peaceful settlement of disputes involving this activity and for creating appropriate international judicial and arbitration entities.

For the first time this document will secure standards of conducting scientific marine studies for all states and competent international organizations.

But we cannot fail to consider that our position in matters of ocean development, shared by the overwhelming majority of progressive, developed and developing states of the world, differs from the position of the United States and large imperialist powers following it which are attempting to use the ocean expanses above all as a springboard for the struggle for world domination as well as for expansion and coercion. This is clearly reflected in their military doctrines, which are actually oriented on the so-called "ocean strategy," reflecting not only military, but also fundamental economic and political interests of western countries in the ocean, and those of the United States above all. In conformity with the course of their postwar policy, they are continuing to seek new supplementary opportunities for resolving one of the most important problems of their policy--establishment of domination in the ocean, which is a part of the concept of winning world supremacy which they declared long ago.

An important role is set aside for study of the ocean and expansion of the development of its biological, raw material and other resources in accomplishing the tasks set by the 26th CPSU Congress for the USSR's further economic and social development. This requires enormous efforts not only of groups of scientists, but also of a large number of practical businessmen. A rational system of economic management in the hydrosphere has to be created and affairs conducted so that its reserves are not exhausted, with thought given not only to today, but also tomorrow. The question of preserving and reproducing ocean resources has to be resolved just as keenly and comprehensively as is their very use.

In discussing the military aspect of the "man-ocean" problem we must proceed from the persistent striving for peace by our party and state. It is important to turn the ocean into a zone of peaceful and mutually advantageous cooperation of all countries, setting a detente policy in opposition to a policy of aggravating international tension and preparing for a new world war being conducted by the present U.S. administration and countries of the aggressive NATO bloc following it. An important place in these preparations is being given to naval warfare, which forces us, in resolving the overall problem of national defense, to take steps to eliminate the growing threat from ocean axes. Creation and development of the Soviet oceangoing fleet--a reliable guarantee of the Soviet Union's security against attack from the sea--is connected with this.

Soviet navymen live with the same interests and thoughts as their people. They stand reliably on guard over the peaceful labor of the builders of communism and socialism's achievements. All naval personnel are responding to resolutions of the November 1982 CPSU CC Plenum and to the statements and conclusions of CPSU CC General Secretary Yu. V. Andropov which he expressed in the speech at the Plenum with a total straining of efforts in the struggle to achieve higher goals in combat readiness, service and training, and with new patriotic initiatives in socialist competition, and thus they are making a growing contribution toward a further reinforcement of national defenses.

FOOTNOTES

1. Of the more than 168 states existing in the world, only some 30 do not have their own sea coast.

2. SEA TECHNOLOGY, March, 1974.

3. S. V. Mikhaylov, "Mirovoy okean i chelovechestvo" [The World Ocean and Mankind], Moscow, Ekonomika, 1969, p 3.

4. MIROVAYA EKONOMIKA I MEZHDUNARODNYYE OTNOSHENIYA, No 9, 1976, p 26.

5. "Bol'shaya Sovetskaya Entsiklopediya" [Great Soviet Encyclopedia], Vol 18, 1974, p 988.

6. PRAVDA, 24 March 1978.

7. Osokin, S. D., "Mirovoy okean" [The World Ocean], Moscow, Prosveshcheniye, pp 96, 98.

8. A product of complex physical and chemical processes of precipitation of metals and other elements from the sea water and depositing around a neutral nucleus.

9. The shallow part of the seabed to depths of 200-500 m which rings the land comprises some 8 percent of the total seabed area.

10. MIROVAYA EKONOMIKA I MEZHDUNARODNYYE OTNOSHENIYA, No 10, 1977, p 76.

11. "Problema issledovaniya i osvoyeniya Mirovogo okeana" [The Problem of Exploring and Developing the Ocean], edited by A. I. Voznesenskiy, 1979, Leningrad, Sudostroyeniye, p 237.

12. See "Materialy XXVI s"yezda KPSS" [Materials of the 26th CPSU Congress], Moscow, Politizdat, 1981, p 145.

13. KOMMUNIST, No 4, 1981, pp 84-90.

14. MORSKOY SBORNIK, No 3, 1981, p 75.

15. JOURNAL OF THE ROYAL UNITED SERVICES INSTITUTE FOR DEFENCE STUDIES, No 4, 1972, p 15 .

16. L. I. Brezhnev, "Za spravedlivyy, demokraticheskiy mir. Za bezopasnost' narodov i mezhdunarodnoye sotrudnichestvo" [For a Just, Democratic Peace: For the Security of Nations and International Cooperation], Moscow, Politizdat, 1973, pp 42-43.

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CSO: 1801/122

UDC 551.326.7

NUMERICAL MODEL OF WIND DRIFT OF ICE WITH ALLOWANCE FOR APPEARANCE OF MAXIMUM CONTINUITY ZONES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 26 Feb 81, after revision 20 Jul 81) pp 1003-1006

SEMENOV, Ye. V. and TARAN, B. M., Institute of Oceanology, USSR Academy of Sciences

[Abstract] In this article, within the framework of a simple model of a continuous medium, based on an Eulerian approach to the description of movement, an attempt is made to take into account some basic effects related to formation of zones of maximum continuity of the ice cover. These effects include the incompressibility of these zones, absence of movement along the normal to the shore in the entire zone, restructuring of the field of velocities of movement of ice with formation of continuous (very closely packed ice) zones within the region. The use of the Eulerian approach was dictated by the simplicity of the numerical method for solving the problem. It is assumed that the movement of the ice cover with values of the "continuity function" below the maximum $(0 \leqslant S < 1)$ is described within the framework of a two-dimensional model of a viscous compressible fluid. With the developed approach, a series of numerical experiments was carried out in a model basin with an E-W extent of 400 km and a N-S extent of 200 km with an island and peninsula measuring 50 x 50 km. The western, southern and eastern boundaries were assumed to be solid and the northern boundary liquid. In all the considered cases the initial ice distribution over the basin was considered uniform and denoted S^0. The numerical experiments revealed some relationships between the initial ice distribution, wind direction and velocity and extent of the forming polynias. These relationships are illustrated in a series of figures; the picture changes with variation of the mentioned parameters. There is a direct linear dependence between the initial ice distribution S^0 and the dimensions of the polynias which are formed with different wind directions. On the other hand, there is a nonlinear relationship between the wind velocity and the width of the forming polynia. Figures 2; references 6: 4 Russian, 2 Western.
[7-[illegible]3]

UDC 551.466.2

KINETIC EQUATION AND KOLMOGOROV SPECTRA IN WEAKLY TURBULENT THEORY OF WIND WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 1 Mar 82) pp 970-979

ZAKHAROV, V. Ye. and ZASLAVSKIY, M. M., Institute of Oceanology, USSR Academy of Sciences

[Abstract] The authors have published here the first of a series of studies on the weakly turbulent theory of wind waves. This first article in the series discusses the properties of the collision term I_N in the key kinetic equation and its precise stationary solutions for a definite type of Kolmogorov spectra. The next paper will deal with the pumping term p^+ and the dissipation term p^- in this same fundamental equation, as well as conditions in the neighborhood of the spectral maximum k_m and the pumping and dissipation intervals. The third article will deal with the corollaries of the equation relating to the form of the spectrum of wind waves outside the pumping and dissipation intervals. The final article will give derivation of a differential equation describing the evolution of the parameters of the spectrum of wind waves and a discussion of the corollaries of this equation. Thus, in this article, on the basis of experimental data on the closeness of the energy-carrying components of adequately well-developed wind waves to linear free waves, use is made of the kinetic equation of the approximation of weak turbulence that takes into account nonlinear interactions, pumping from the wind and dissipation. Also examined are special features of this approximation associated with the manifestation, in addition to the usual dynamic laws of conservation of momentum and energy, of a law of conservation of the wave effect specific for slightly nonlinear gravitational waves. In particular, it is demonstrated that in an anisotropic case (when the wave momentum is equal to zero) there are two alternative Kolmogorov power-law spectra determined by the energy and action fluxes respectively which are precise stationary solutions of the kinetic equation outside the pumping and dissipation intervals. Figures 1; references 12: 10 Russian; 2 Western.
[7-5303]

UDC 551.463.5:535.36

SPATIAL FLUCTUATIONS OF UNDERWATER ILLUMINATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 1 Apr 81) pp 953-962

VEBER, V. L., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] In a theoretical formulation the problem of determining such important characteristics of the random field of illumination as the dispersion of fluctuations, spatial-temporal correlation function and energy spectrum

is exceedingly complex. Clarification can be brought about by simplification of the initial model. The author's objective was to obtain quite a simple and physically sound analytical evaluations of the dispersion and correlation radius of the fluctuating illumination field. This objective is achieved by the application of a number of simplifications and idealizations in formulation of the problem and in the course of its solution. These idealizations, on the other hand, are no more extreme than those common in solving similar problems. Specifically, the author examines a scheme for measuring illumination in which the light source (sun) of a stipulated brightness illuminates a randomly uneven nonstationary interface of media with different refractive indices (water-air discontinuity) normal to its mean level. Under water at the depth h there is a device for measuring illumination; the coefficient of refraction for water is m > 1, for air -- m = 1. It is assumed that the measurement device is ideal and the medium (water) neither scatters nor absorbs light radiation (is optically transparent). A number of effects are not taken into account, such as the effect associated with the finite height of waves on the interface. This formulation made it possible to examine some statistical characteristics of underwater illumination fluctuations. Definite analytical expressions are derived for evaluating dispersion and correlation radius of the illumination fluctuation component. Figures 3; references: 12 Russian.
[T-5303]

UDC 551.463

FORMING OF DEEP WATERS IN WORLD OCEAN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 3, Jan 83
(manuscript received 6 Jul 82) pp 713-716

MAMAYEV, O. I., Moscow State University imeni M. V. Lomonosov

[Abstract] Iselin was the first to point out that over an extensive area of the North Atlantic the T-S curves for the ocean surface virtually coincide with the T-S curves for deep ocean stations in the same region. This was attributed to the formation of deep waters by the subsidence of waters from the surface along the isopycnic surfaces coinciding with the corresponding isothermic and isohaline surfaces. Sverdrup later indicated that if the T-S curves at the sea surface and in the deep layers do not coincide, this must be evidence that in addition to isopycnic movement there must be processes of mixing across the isopycnic surfaces. These ideas served as the basis for the hypothesis that the so-called central water masses of the oceans are formed as a result of isopycnic subsidence and/or direct convection from the ocean surface. The linear regressions between salinity and temperature for the surface of the Atlantic, Indian and Pacific Oceans and for the surface of the entire world ocean derived in a number of later studies, together with linear and nonlinear T-S expressions for the entire volume of waters in these same oceans and for the entire world ocean which are presented in this article, can be compared and make possible a clearer comprehension of the

picture of formation of deep waters. It is shown that there is a surprising similarity between the T-S expressions for the surface of the world ocean and the entire volume of the ocean. The corresponding regression lines lie very close to one another, although they do not coincide. It is demonstrated that the formation of deep waters from surface waters may indeed not be purely isopycnic in certain regions and appears to involve verticle convection mixing. Although the T-S expressions for surface and deep waters do not coincide at the scale of the world ocean, it does not follow that they do not coincide for some limited ocean areas. The Iselin hypothesis is therefore essentially valid. Figure 2; references 9: 5 Russian, 4 Western.
[70-5303]

UDC 550.834.08

STRUCTURE OF EMPEROR FAULT IN NORTHWESTERN PACIFIC OCEAN ACCORDING TO DEEP SEISMIC PROFILING--REFLECTED WAVES DATA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 3, Jan 83
(manuscript received 15 Jun 82) pp 710-713

KOGAN, L. I. and SHMIDT, O. A., Southern Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Gelendzhik; Geological Institute, USSR Academy of Sciences, Moscow

[Abstract] The Emperor zone of faults in the northwestern Pacific Ocean extends for 2500 km and has a width of aoubt 150 km. It consists of narrow, elongated and deep valleys and individual crests with an echelon arrangement. The area was investigated on the 23d voyage of the "Dmitriy Mendeleyev" in 1979 when a run with a length of 100 km was made normal to the direction of the fault. The work method is briefly described and the characteristics of the collected data are discussed. (Fig. 1 is a map of the area in which the work was done; Fig. 2 is a schematic seismogeological section along the run). The study revealed that the crust along the northeastern and southwestern margins of the fault has an identical structure with a somewhat greater thickness in the second case. A block structure of the crust is very well expressed along the entire profile. There is a decrease in the extent of the blocks from 15 to 5 km with approach to the axis of the fault and the amplitude of the displacements along the faults separating the blocks increases in the direction of the fault axis. In the zone of the margins and especially in the trench zone the crust is broken into small blocks with an extent from 0.5 to 3.0 km; the amplitude of the faults here is 0.5-1.0 km, sometimes attaining 3.0 km. It is postulated that the pattern of fault tectonics observed in the cross section is caused by dilatation. The crustal structure in the axis of the fault differs from the margins only by having an increased thickness of the sedimentary layer (0.5 km), volcanic sediments (0.8 km) and fragmentation into small blocks. In contrast to faults in the Atlantic, where rising of rocks of the third layer and mantle to the bottom surface is observed, such a phenomenon is absent or poorly expressed in the Emperor fault. The Emperor fault is expressed by a series of elongated grabens caused by regional dilatation of the earth's crust, probably caused by the disharmonious movement of large sectors of the oceanic crust. Figures 2; references: 4 Russian.
[70-5303]

UDC 551.465.4(269)

INVESTIGATING TRANSPORT OF WATER MASSES IN CIRCUMPOLAR CIRCULAR CURRENT USING TRITIUM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 1, Jan-Feb 83
(manuscript received 23 Apr 82) pp 217-219

BOROUKHIN, Ye. A., KOBYLYANSKIY, V. V. and POZDEYEV, Yu. S., Pacific Ocean Oceanological Institute, Far Eastern Scientific Center, USSR Academy of Sciences, Vladivostok

[Abstract] The half-life of tritium (12.43 years) makes it possible to detect the slow transport of waters with a high tritium content with time scales of movement up to several decades. Quite high tritium concentrations have been discovered in the surface and deep waters of the circumpolar current and this has made it possible to seek the region of entry of surface tritium into bottom antarctic waters. Measurements of the tritium concentration made in 1981 on a run along 152°E made it possible to ascertain the present-day tritium content and its spatial distribution, very significant for studying the transport of water masses in this region. The samples were taken during the 29th voyage of the "Professor Vize"; full statistical data are given in a table. The results indicate that the tritium concentrations in circumpolar waters had not changed since 1972. The depth of penetration of the surface concentrations of tritium in subantarctic waters was greater than in earlier observations, at 47°S attaining 1000 m. Two stations, situated on either side of the zone of Antarctic convergence, at 53 and 54.8°S, revealed a great horizontal gradient of tritium concentrations at 500 m and indicate an insignificant participation of Antarctic deep water to the south of the front in the formation of waters of the polar frontal zone. Tritium can be used not only in studying the vertical profiles of water masses, but also water masses in the horizontal plane. The very high tritium concentration in bottom water at 65°S is a result of intensive entry of surface waters into bottom waters as a result of local or seasonal convergences. The tritium content in deep and bottom waters and hydrological concepts concerning oceanic circulation of the Antarctic Ocean preclude the possibility of penetration of such tritium quantities from the north. The only Antarctic area which could be a source of such tritium concentrations is the eastern boundary of the Ross Sea ice shelf. There is a westernly transport from the Ross Sea along the shelf slope of Antarctica to the south of the Balleny Islands in both the surface and bottom layers. The region of high tritium concentrations has a considerable extent in both latitudinal and meridional directions and therefore can be used in estimating the rate and direction of transfer of antarctic deep water. Figures 1, tables 2, references 5: 1 Russian, 4 Western.
[37-7323]

UDC 550.4:551.35(267.5)

MANGANESE BALANCE AND ORE FORMATION IN OCEAN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 1, Jan-Feb 83
(manuscript received 22 Apr 82) pp 214-216

BATURIN, G. N., Institute of Oceanology imeni P. P. Shirshov, USSR Academy
of Sciences, Moscow

[Abstract] Ferromanganese nodules are the principal form of solid mineral in the ocean, but few reliable data have been published on the manganese balance. The author attempts to solve this problem on the basis of data on the geochemistry of manganese and the absolute geochronology of ocean deposits. The ocean receives manganese in the form of suspended and dissolved Mn in river water, underground and glacial runoff, abraded, eolian, volcanic and hydrothermal material. The total inflow of manganese into the ocean is 22-27 million tons annually. An effort was made to determine the differing rates of sedimentation in different parts of the ocean. It was broken down into the following zones: 1) peripheral continental zone, area 87 million square kilometers, mean rate of sedimentation 25 $mg/m^2 \cdot year$ and Mn content in sediments 0.06-0.07%; 2) zone of hemipelagic and pelagic sediments--220 million square kilometers, ~ 1 $mg/m^2 \cdot year$, $\sim 0.4\%$; 3) pelagic zone of ore fields (without allowance for surface of Fe-Mn nodules)--50 million square kilometers, ~ 0.1 $mg/m^2 \cdot year$, $\sim 1\%$; 4) zone of ore fields occupied by nodules--5-10 million square kilometers or 10-20% of the area of the ore fields and 1.4-2.9% of the area of the oceans. In estimating the absolute mass of increment of nodular matter it was assumed that their total mass at the bottom surface is 500 billion tons. With an average Mn concentration in the nodules of 20% and an average age of the nodules according to radiometric data from 1 to 10 million years the annual increase in the mass of nodular matter is $50\text{-}500 \cdot 10^3$ tons of manganese. Despite a minimum flux of diffuse Mn from oxidized pelagic sediments, this ensures the absolute mass of Mn necessary for maintaining the growth of ferromanganese nodules with the mean rates which have been determined by radiometric methods. The mass of manganese expended in the formation of ore nodules is an insignificant fraction of the mass of metal participating in the sea sedimentary cycle--about 0.1-0.3% of its total receipts in the ocean and 0.5-1% of its geochemically active mobile forms. Tables 1; references 15: 10 Russian, 5 Western.
([illegible])

UDC 551.466:550.344.42

ACOUSTIC MECHANISM FOR EXCITATION OF TSUNAMI WAVES

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 22 Jun 81) pp 693-697

NOVIKOVA, L. Ye. and OSTROVSKIY, L. A., Institute of Applied Physics, Gor'kiy

[Abstract] In an effort to clarify the acoustic mechanism of excitation of tsunami waves the authors investigated the nonlinear mechanism of excitation of tsunamis related to the detection of oscillatory acoustic disturbances in the water. The disturbances considered may be related to rereflection of the compressional force excited by displacement or to elastic bottom oscillations. A relatively simple case is examined when the front of the acoustic wave is horizontal and the acoustic oscillations are localized in the space under the displacement region, a model which is approximately correct for both rereflections of compressional waves and for sound excited in the bottom by an elastic wave; in other words, a tsunami wave can be excited by two sources--directly by bottom displacement and by the averaged effect of the acoustic field. The averaged nonlinear disturbances, although small in comparison with the linear disturbances, have a duration corresponding to the tsunami momentum and therefore can be an effective source for a surface wave. The acoustic mechanism can give a definite contribution to tsunami energy even in the case of subsonic velocities of displacement. Evaluatations presented here show that this mechanism may be predominant for adequately rapid displacements. The acoustic mechanism can play an exceptionally strong role for sources of an explosive type, such as a volcanic eruption. Figures 2; references 3: 2 Russian, 1 Western.
[11-5303]

UDC 551.465.11

NONLINEAR THEORY OF MACROSCALE CURRENTS OVER ANISOTROPIC BOTTOM RELIEF FOR TWO-LAYER OCEAN MODEL

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 3 Jul 81) pp 698-703

VOLOSOV, V. M. and ZHDANOV, M. A., Institute of Oceanology imeni
P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] V. M. Volosov laid the basis for this investigation in a series of papers on nonstationary currents over anisotropic bottom relief in a linear approximation with allowance for nonlinear terms in a homogeneous ocean in OKEANOLOGIYA, Vol 16, Nos 3, 5, 6, 1976. Then, in this same journal (Vol 20, No 1, 1980) such currents with a small amplitude (in a linear approximation) were examined for a two-layer model of the ocean and then the same problem was studied for a continuously stratified ocean (Vol 20, No 4, 1980). Proceeding on this basis, V. M. Volosov and M. A. Zhdanov now investigate macroscale nonstationary currents of a finite amplitude (the nonlinear terms

are retained in the equations) over anisotropic microscale bottom relief for a two-layer model of the ocean. A nonlinear equation is derived for the macroscale component of movement, as well as expressions for determining the parameters of currents of a topographic scale. After presenting a physical interpretation of the results, the authors present an example of numerical computations of nonlinear periodic waves over sinusoidal bottom relief. This is followed by a comparison with data on bottom relief from the literature. Figures 2, tables; references 8: 6 Russian, 2 Western.
[11-5303]

UDC 551.46.08

NUMERICAL EXPERIMENTS WITH BAROTROPIC QUASIGEOSTROPHIC MODEL OF SYNOPTIC MOVEMENTS IN OPEN OCEAN REGION

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 31 Dec 81) pp 719-725

KAMENKOVICH, V. M., LARICHEV, V. D. and KHAR'KOV, B. V., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] This is essentially a continuation of an earlier article by the authors entitled "Numerical Barotropic Model for Analysis of Synoptic Eddies in an Open Region of the Ocean" (OKEANOLOGIYA, Vol 21, No 5, pp 773-786, 1981). The materials in that paper are reviewed. Then, by a comparison of numerical and precise solutions of a problem approximately describing some peculiarities of synoptic eddies in the ocean, it was possible to evaluate the accuracy of barotropic quasigeostrophic forecasts for the open region of the ocean with different values of the determining parameters and also different fixed boundary conditions. It is shown that determination of the boundary conditions is the most difficult part of the problem but is highly important because errors in setting the boundary conditions are gradually propagated within the region. Possible ways to improve accuracy in this part of the work are examined (it is noted that certain aspects of this problem have been examined by A. R. Robinson, et al. in J. PHYS. OCEANOGR., Vol 10, No 12, pp 1909-1928, 1980). The different tests used in evaluating the accuracy of prediction of the overall forecast are discussed in detail. Figures 8, tables 5; references 8: 4 Russian, 4 Western.
[11-5303]

UDC 551.553

COMPUTATION OF MEDITERRANEAN SEA WIND CURRENTS BY ELECTRIC MODELING METHOD (ONE-DIMENSIONAL MODEL)

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 7 Jul 81, after revision 3 Mar 82) pp 726-732

MENZIN, A. B. and MOSKALENKO, L. V., Leningrad Hydrometeorological Institute

[Abstract] The article describes stationary wind currents in the Mediterranean Sea obtained by the electric modeling method. This model was developed using the "total flows" (transport stream function) method for a homogeneous sea of variable depth. The modeling was carried out to a depth of 200 m. Maps of Mediterranean wind currents for the winter season are reproduced as Fig 1a, 1b. According to the modeling, in the western part of the sea during this period there is a predominance of a cyclonic circulation of waters. The cyclonic systems of the Alboran Sea and the Algerian-Provence Basin are separated by a poorly expressed anticyclonic circulation system; for the most part a cyclonic system is also characteristic of the eastern part of the sea. Winter circulation is attributable to the distribution of atmospheric pressure, the wind field and the vorticity of wind shearing stress above the sea surface. As shown in Fig. 2, in winter when low pressure prevails over the entire sea, a positive vorticity of wind shearing stress, excited by the cyclonic circulation of water, predominates. The summer wind circulation differs from that in winter; in summer an anticyclonic circulation develops in the sea, predominating in the western and central parts, whereas in the eastern part of the sea a cyclonic movement of water predominates. The principal characteristics of summer circulation are also easily attributable to the atmospheric pressure and wind fields; negative vorticity develops. The direction of the prevailing winds remains northwesterly, but in contrast to winter the meridional component of wind shearing stress is greater than the zonal component. In winter water circulation in the sea, especially in its eastern part, has a clearly expressed latitudinal development, but in summer a meridional development. The authors compare these modeled circulation maps with data from other computations and dynamic maps for winter and summer. The modeled maps of currents in the western part of the sea differ considerably from the dynamic maps. The significant differences in maps of currents in the western Mediterranean obtained by different methods indicate that the considered model does not reflect real conditions and that the effect of the wind on the circulation of waters in this part of the sea is not decisive. In the modeling of the circulation of waters in the western Mediterranean it is also necessary to take into account exchange of Mediterranean waters with the Atlantic and the density stratification of waters. Thus, the nature of currents in the western part of the sea requires special investigations. Figures 4; references 6: 5 Russian, 1 Western.

[11-5303]

UDC 551.46.08

CHARACTERISTICS OF FINE STRUCTURE OF CURRENT VELOCITY IN OCEAN

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 3 Apr 81, after revision 7 Sep 81) pp 733-737

VARLATYY, Ye. P., PYZHEVICH, M. L. and SUKHOV, A. L., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] At the present time very few data are available concerning the fine structure of the current velocity field in the ocean. Data on the fine vertical structure of the current velocity field were collected in various regions of the Pacific Ocean during the 22d voyage of the research ship "Dmitriy Mendeleyev." Measurements were made with an acoustic apparatus in a vertical sounding regime for determining the intensity and direction of the current relative to the ship in the range of change of flow velocity 0-2 m·sec^{-1} and direction of flow 0-360°. The accuracy in measuring velocity was 3 cm·sec^{-1} and for direction 3°. The measurements were made from a drifting ship; the rate of sounding was close to 0.5 m·sec^{-1}. The velocity profiles were made with a discreteness of 4 m; there were 162 points in a series; the first point corresponded to a depth of 20 m. A shipboard computer was used in computing the meridional v and zonal u current velocity components, their gradients, the square of the current velocity gradient, the first four moments and empirical distributions of these parameters and the spectral densities of current velocity inhomogeneities. The influence of individual "surges" was reduced by using low-frequency filtration of the initial series by a cosine filter. These multiple soundings in different regions revealed a difference in the spatial-temporal variability of fine structure of the current velocity field. As an example, the article gives full data for observations made at station 1785. Figure 1 shows that the structure of the vertical profiles is characterized by an unordered alternation of layers with small and great vertical gradients with depth. Figures 2 and 3 show the empirical distributions of the gradients of the zonal and meridional velocity components and the square of the absolute gradient. Figure 4 illustrates the spectral densities of vertical inhomogeneities of the zonal and meridional current velocity components. Although highly informative, the data do not allow any determination of the mechanisms of formation and variability of fine structure of the velocity field. Figures 4, tables 1; references 7: 5 Russian, 2 Western.
[11-5303]

UDC 551.46.09:551.465.15:628.5

NON-SELF-SIMILARITY OF CONCENTRATION DISPERSION DURING TURBULENT DIFFUSION IN SEA

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 17 Jun 81) pp 738-743

TOOMPUU, A., Institute of Thermophysics and Electrophysics, Estonian Academy of Sciences, Tallin

[Abstract] The dispersion of concentration fluctuations is one of the statistical characteristics giving some idea concerning variability of the concentration field. G. T. Csanady (J. ATMOS. SCI., Vol 24, No 1, pp 21-28, 1967; GEOPHYS. AND ASTROPHYS. MONOGRAPH, Vol 3, 1973) proposed a model describing the transformation of dispersion of the concentration from a point continuously operative source but published experimental data in certain cases do not agree with the Csanady model, dictating a reexamination of the problem. Accordingly, the author proposes a new model for describing the dispersion of concentration in a jet of passive admixture generated by a continuously operative source in a homogeneous turbulent medium with some non-zero mean velocity relative to the source. It is shown that it is not the finite size of the source which is one of the decisive dispersion factors, as is asserted elsewhere in the literature, nor is it the limitation of the concentration at the source, but rather the limitation of H(r,x) (with limitation of the dissipation rate) [H(r, x) has the sense of the density distribution of intensity of the sources] in the entire space, including the source, since the finite size of the source in general is not an adequate condition for existence of limited H(r, x). This and other findings were applied to the results of experimental studies made in the Baltic Sea by Yu. Pavel'son, et al., OKEANOLOGIYA, Vol 19, No 6, pp 1016-1020) in order to test their validity. In those experiments in all five sections of a diffusing jet at distances from the source of 25, 75, 150, 250 and 350 m the distribution of the mean concentration was close to Gaussian. Accordingly, the conclusions from the model are in qualitative agreement with experimental data and there is no non-self-similarity of the concentration dispersion profiles. Figures 2; references 12: 3 Russian, 9 Western.
[11-5303]

UDC 551.463.8

INFLUENCE OF UPPER HOMOGENEOUS LAYER ON DIFFUSION OF RADIOACTIVE FALLOUT IN OCEAN

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 23 Jan 81, after revision 9 Nov 81) pp 744-749

VINOGRADOV, A. S., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] It has been assumed that due to a high exchange intensity the flux of isotopes at the upper boundary of the thermocline differs little from the

flux of isotopes at the ocean surface. However, since a considerable percentage of the isotopes falling on the ocean surface is contained in the upper homogeneous layer this layer should exert an effect on the change in the concentration of isotopes. The decay of the isotopes should also exert an effect. Accordingly, the author employed a two-layer model in examining the problem of vertical diffusion of cosmogenic and artificial radioactive fallout in the ocean. An integral approach is applied to the upper homogeneous layer and the transport of isotopes in the lower layer (thermocline) is described by the ordinary nonstationary diffusion equation. It was found that the upper homogeneous layer decreases the mean level and range of fluctuations of the surface concentration, accelerating the transport of isotopes into the deep layers. With the passage of time the influence of the upper homogeneous layer on the distribution of artificial isotopes is lessened and the layer which is homogeneous with respect to the concentration of isotopes is gradually propagated to the thermocline, this resulting in a decrease in the variability of the surface concentration of isotopes. It is shown that the presence of the upper homogeneous layer results in a flow of isotopes from the equatorial zone into the temperate latitudes. In regions where the thermocline degenerates there should be an intensified transfer of isotopes into deeper layers under the influence of winter convection. The influence of the upper layer is greater for artificial isotopes, which in contrast to cosmogenic isotopes do not have a steady regime. Figures 2, tables 2; references 8: 7 Russian, 1 Western.
[11-7303]

UDC 551.462(261.4)

ROLE OF DYNAMIC AND STATIC FACTORS IN RELIEF FORMATION IN NORTHERN PART OF MID-ATLANTIC RIDGE

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 18 May 81, after revision 23 Oct 81) pp 781-788

LUKASHEVICH, I. P., PRISTAVAKINA, Ye. I. and SOROKHTIN, O. G., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] In the O. Sorokhtin crystallization model of formation of the oceanic lithosphere (DOKL. AN SSSR. Vol 208, No 6, 1978) lithospheric plates must be in a state of hydrostatic equilibrium. The free-air gravitational anomaly over them should be close to zero. However, over the North Atlantic ([illegible]) there is a major positive anomaly, becoming negative at about [illegible]. The positive anomaly can be attributed to an excess of mass, whereas the negative anomaly can be attributed to a deficiency of mass. Here the authors examine these effects from the point of view of the Sorokhtin model. The following conditions for the cooling of the upper mantle are assumed: linear heat flow, absence of a convective component and internal heat sources and constant thermal conductivity coefficient. It was further assumed that with a change in the aggregate state of the upper mantle from partially molten to solid the physical parameters change in a jump and that the latent heat of crystallization is released at the transition boundary (the problem is examined separately for three age intervals). Full information is given on the results of processing of profiles of the acoustic basement intersecting the Mid-Atlantic Ridge. These and other data made it possible to determine the bathymetric characteristics and the position of the normal profile, which is in a state of hydrostatic equilibrium. By studying the density characteristics of the upper mantle under these profiles it was possible to demonstrate within what limits the bottom topography and the free-air anomaly still can be attributed to the static factor (change in the physical parameters of the lithosphere and asthenosphere). Outside these limits the leading role is played by the dynamic effect (such as the convective flow). It is noted that these findings are applicable only to regions of the ocean for which the age of the lithosphere is greater than 60 million years and the depths are greater than 5 km. Figures 2, tables 3; references 24: 16 Russian, 8 Western. [11-1[illegible]]

UDC 551.46[illegible].6(261.26)

RESULTS OF INTERPRETATION OF NORTH SEA HYDROMAGNETIC SURVEY

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 18 May 81) pp 789-794

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[Abstract] During 196[illegible]-1978 specialists of the Leningrad Division, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation carried out a hydromagnetic survey in the North Sea. The geomagnetic field of the North Sea has now been studied quite thoroughly by the "Zarya," making it possible to compile the map of the anomalous magnetic field at 1:2,000,000 which forms part of this article. This T_a map shows that the anomalous magnetic field is not uniform in structure. This made it possible to define individual regions on the basis of a combination of criteria: field intensity and differentiation; orientation and extent of anomalous zones and their distribution in area; predominance of sign of anomalous field; depth of sources. As indicated by the relationships between the magnetic field and geological structure established on the land, these characteristic criteria reflect the petrographic composition of magnetized geological features and their spatial distribution, as well as the strike of the principal geotectonic structures. On the basis of these criteria three regions were defined. Region I -- The northern part of the sea between 57 and 60°N, characterized by a combination of annular and linear anomalous zones of a sustained northeasterly strike. Region II -- The eastern part of the sea between 3°E and Jutland, where there are anomalous zones of a submeridional strike, separated by zones with a relatively reduced field, the width of the zones being [illegible] km, traced for a distance of more than [illegible] km from the shores of the Netherlands to the Scandinavian Peninsula. Region III -- Situated between the meridian 3°E and the eastern shores of the British Isles, characterized by a relatively reduced

field. In the North Sea the magnetic survey data were used in making more than 200 determinations of depths to the top of magnetized bodies. On the basis of these data, with allowance for the depths to the crystalline basement, it was possible to construct a schematic tectonic map of the North Sea, which is reproduced here. Figures 2; references 17: 8 Russian, 9 Western. [11-5303]

UDC 551.463.2

FREQUENCY-TIME HYDROLOGICAL SPEED-OF-SOUND INDICATOR

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 18 May 81, after revision 25 Nov 81) pp 839-843

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[Abstract] Pulsed-cyclic instruments for measuring the speed of sound in sea water have a series of limitations when carrying out hydrological measurements: low response, due to the finite dimensions of the acoustic base; low noise immunity, resulting in gaps, when there is impairment in the acoustic transparency of sea water in layers saturated with air or microorganisms; presence of a random error due to parasitic echo signals on the acoustic base. Moreover, the traditional design of the acoustic system used in measuring the speed of sound, when there are changes in the attenuation of sound in sea water, gives rise to an increase in the probability of a jumplike change in the time of registry of the received signal by one half-wave in the radio pulse due to the small steepness of its leading edge. The authors have developed a speed-of-sound indicator based on the frequency-time method which eliminates the mentioned shortcomings. This new indicator consists of primary, intermediate and secondary transducers; these are illustrated and described in detail (8, 18 and 5 components are identified). The proposed acoustic system makes it possible to obtain a signal in the form of a radio pulse consisting of two periods of a resonance frequency in which the second half-wave has a maximum amplitude; this virtually eliminates the "jump" phenomenon. The apparatus is constructed of integrated microcircuits requiring a low consumption of power and has a high noise immunity. Current supply is from independent sources. The required power does not exceed 240 mW (12 V; 20 mA). The measurement range is 1400-1600 m·sec^{-1} with a sea water temperature from -2 to +31°C and submergence depths to 2000 m. Recommendations on use of the apparatus are outlined. Figures 2; references: 2 Russian. [11-5303]

UDC 551.463.2

DIGITAL SYSTEM FOR REGISTRY OF HYDROACOUSTIC DATA ON MAGNETIC RECORDER

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 14 Apr 80) pp 844-847

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[Abstract] The registry of rapidly transpiring and periodically repeating processes is required in solving many problems in hydroacoustics. This article describes a portable digital system for registry of signals of the corresponding type on a magnetic tape. In the data registry unit provision is made for a buffer memory unit which makes possible the rapid registry of the informative part of the signal in the buffer memory unit and slow reregistry of data from the buffer memory unit onto the magnetic tape. The dynamic range of the registry system is 256 levels and the time of continuous registry is 45 minutes. It was possible to increase the frequency of quantization of the input signal to 6 KHz with a rate of registry of 200 readings/sec. The low rate of registry on the magnetic recorder makes it possible to dispense with the use of special multitrack digital magnetic recorders and employ an ordinary magnetic recorder with registry of data in a sequential code on one track of the magnetic tape. A block diagram of the unit for the registry of data on a magnetic tape is illustrated and the operating principle is discussed in detail. In the described registry system use was made of two methods for the registry of data on magnetic tape. The first method is two-level registry with phase modulation of the pulses and is a common method. The second method is the registry of pulses with amplitude modulation; being a less common method, it is fully described. A block diagram of the input unit is given and described. The described digital registry system can be employed successfully not only for the registry of hydroacoustic information, but also in investigating other periodically repeating processes requiring a quite high quantization frequency, especially in investigating internal waves and the fine structure of cold films on the sea surface by the multiple soundings method. Figures 4; references: 8 Russian.
[21-5303]

UDC 551.46.07

METHOD FOR STATISTICAL ANALYSIS OF BOTTOM RELIEF DATA USING ELECTRONIC COMPUTER

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 24 Feb 81, after revision 22 Jul 81) pp 848-851

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[Abstract] The constantly increasing flow of data on bottom geomorphology requires further development of methods for the processing, analysis and

storage of data. Specialists at the Atlantic Division, Institute of Oceanology, over the course of some years have developed a method for the large-scale analysis of data by a breakdown of the relief curve into the elements determining it: slope angles, vertical and horizontal dissection. The proposed method makes it possible to carry out an analysis of materials of two types: data obtained directly on expeditions and information selected from albums of profiles prepared on the basis of expeditions carried out earlier. The expeditionary data in the form of the coordinates of points, depths and the time of their registry are coded and successively introduced into a computer for processing in accordance with the special "Rel'yef" program. After correcting depths by introducing a correction for the speed of sound in sea water the observed data are converted into a relief profile at a linear scale. Relief data can be punched or stored in the computer memory. Such profiles are one of the results of processing of data from geomorphological investigations and are constantly constructed in the course of voyages on ships of the Institute of Oceanology. The program provides for the printout of the initial series and corrected depths. Using this same program, the resulting profile is used in forming a working mass of data for subsequent processing under the "Statistika" program. Specific procedures are described. The "Statistika" program ensures obtaining a broad range of morphometric indices. In processing the albums of profiles the information is processed immediately under the mentioned program. The program provides for the possibility of output of histograms: "initial depth," "angles of slope," "vertical and horizontal dissection" and tables of the mean and extremal values of the morphometric parameters. The use of "YeS" computers on ships of the Institute of Oceanology has greatly broadened the possibilities of processing bottom relief data; it has made it possible to increase the data volume to 5000 points, which ensures processing of relief forms as a whole (mid-oceanic ridges, underwater margin of the continent and abyssal basins). Figures 3; references: [illegible] Russian.
[11-3398]

UDC 551.464.001.8

[illegible] FOR MICROSCOPIC ANALYSIS OF MARINE SUSPENDED MATTER

Moscow OKEANOLOGIYA in Russian Vol 22, No 5, Sep-Oct 82
(manuscript received 23 Jun 81, after revision 16 Sep 81) pp 856-858

[illegible], A. M. and CHUVIL'CHIKOV, S. I., Institute of Oceanology imeni
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[Abstract] The work program for the 24th voyage of the "Dmitriy Mendeleyev" provided for analysis of the signal of a laser Doppler anemometer in some sea water samples before and after filtering with a parallel analysis of suspended matter in these same samples. The source of coherent monochromatic radiation was an LG-38 laser. The laser ray was divided into two parallel rays, which after a positive lens intersected in the fluid; the scattered radiation was also registered with an FEU-79 photomultiplier. The investigated water sample (1500 ml) was filtered under hydrostatic pressure through three successively arranged membrane filters with a mean pore size 0.4 μm.

When counting the particles on the filters all were divided into four groups: d<2 μm; 2<d<5 μm; 5<d<10 μm; d>10μm. The microscope magnification was 960. The microscopic analysis of these samples from the equatorial Pacific indicated that the changes in the concentration of suspended matter at depths 50, [illegible], 120-150 m did not exceed 30% of the mean values (3500, 5500, [illegible] particles/cm^3 respectively). The distribution of the particles in the four groups was in the ratio 10:5:2:1. A comparison of data obtained using the laser Doppler anemometry method and the microscopic analysis revealed a good qualitative correspondence between the two methods. However, the LDA almost always registered signals from fine particles which are not registered on the filters. This confirms the known noncorrespondence between the results of a microscopic analysis, on the one hand, and the conductometric and nephelometric methods, on the other. Tables 1; references 10: 7 Russian, 3 Western. [11-5303]

UDC 551.24

LAYERS OF INCREASED WATER TURBIDITY IN TINRO DEPRESSION OF SEA OF OKHOTSK

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 267, No 1, Nov 82 (manuscript received 17 May 82) pp 212-214

SAGALEVICH, A. M. and IVANENKOV, V. N., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] During the 91st dive of the "Paysis" underwater vehicle on [illegible] August 1981 in the TINRO depression of the Sea of Okhotsk specialists discovered earlier unknown thick layers of increased turbidity. The principal objective of the dive was a study of the spectral characteristics of sea noise by sensors mounted on the vehicle. The submersible descended to the bottom at a minimum rate (5 m/min). The echo sounder on the "Akademik Kurchatov," the support ship, registered a depth of the vehicle's descent to [illegible] m. The approach of the "Paysis" to the bottom was monitored by sonar. Activation of the sonar at a depth of 500 m made it possible to detect a clear reflecting boundary at 600 m; the crew erroneously assumed that this was the bottom. A marked increase in biological activity was observed with approach to this boundary. With passage through this 600-m boundary the water became much more turbid and visibility dropped sharply. Living organisms disappeared and the water began to resemble a suspension with particles measuring [illegible] mm. With further descent, distinct reflecting boundaries were observed each [illegible] m; turbidity increased with passage through each of them. After passage through each of the layers the size of the suspended particles decreased with depth. The vehicle came to a halt at [illegible] m, although the bottom could not be seen. It seemed that the vehicle was sitting on a dense fluid mass. The suspended particles forming layers of increased turbidity are unquestionably of an organic origin; only at the bottom does the fraction of particles of terrigenous origin predominate. The terrigenous particles on the average are [illegible] times smaller than those of organic origin. The TINRO depression and the adjacent Kamchatkan and northern shelves are exceptionally

highly productive regions. In layers of increased turbidity the concentration of detritus increases by a facor of 30-40. The disappearance of fauna in layers of increased turbidity is caused by the increased concentration of detritus, not by temperature, oxygen or similar conditions. In the investigated sector there is dominance of a semidiurnal tide with current velocities of 1-3 knots or more, favoring transport of suspended matter from the shelf along the slopes into the depression and making its settling difficult. Cyclonic circulation in the TINRO depression with ascending movements in its central part also impedes the settling of suspended matter. The mentioned processes have already persisted for many tens of millions of years. The layers of increased turbidity explain many characteristics of its hydrochemical structure. The TINRO depression is a highly interesting area for hydrophysicists biologists and geologists. However, the layers of increased concentration of detritus show the infeasibility of deep-water fishing in the TINRO depression. References: 5 Russian.
74-132

TERRESTRIAL GEOPHYSICS

UDC 550.34.056

ALGORITHM FOR RAPID TRANSFORMATION OF FREQUENCY SEISMOGRAMS INTO PULSED SEISMOGRAMS

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 4, Apr 82
(manuscript received 10 Aug 80) pp 103-106

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[Abstract] In vibroseismic reconnaissance methods the duration of continuous radiation of the seismic signal usually exceeds the travel time of the useful waves. In addition, as a result of interference of a great number of prolonged wave trains the observed total wave field cannot be interpreted. Due to the difficulty in solving this complex problem, in addition to ordinary procedures, in vibroseismic methods the signals are additionally transformed into a form similar to the records on ordinary shot seismograms. The presently employed method for accomplishing this is time consuming and costly (2 or 3 hours of computer time are required for processing a single physical observation when employing a BESM-4M electronic computer). In this article the author demonstrates that the problem can be dealt with successfully by application of the FFT (fast Fourier transform) method; this makes possible a dramatic reduction in computer time, as has been observed in solution of a wide range of other physical problems. The article outlines an economical algorithm for transforming the phase-distorted frequency characteristic of the geological medium into a pulsed reaction. Its application shows excellent results in the processing of vibroseismic information obtained by the frequency method. At present the application of the algorithm with a BESM-4M still requires 35-40% more computer time than when using ordinary shot methods; use of a better computer will reduce this to no more than 5-10%. References: 6 Russian.
[182-5303]

UDC 551.1/.3

RESULTS OF MEASUREMENTS OF VIBROSEISMIC SIGNALS AND NOISE DURING VIBRATIONAL DEEP SEISMIC SOUNDING

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 4, Apr 82
(manuscript received 4 Oct 80) pp 89-94

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[Abstract] An 8-channel digital vibrational seismic station has been developed which ensures correlation accumulation and compression of vibroseismic signals along a profile. It has now been tested for evaluating the maximum distance at which correlation accumulation makes possible the reliable registry of regular waves excited by a vibrational source, especially the first arrivals of a longitudinal wave, for sample interpretation of reconstructed pulsed seismograms, for determining the absolute amplitudes of the primary oscillations reaching the seismic detectors at different distances from the excitation point, for measuring accompanying microseisms and real noise immunity of the vibroseismic method and apparatus and for finding some metrological characteristics of the instrument complex. The data used in the analysis were registered at distances of 20, 96, 170 and 286 km from the source of oscillations. The vibrational source used had an amplitude of force [illegible] tons and operated in a frequency range 6-9 cps. At the mentioned distances it was possible to register the waves most important for the deep seismic sounding method, especially those associated with the Conrad and Mohorovicic discontinuities. It has therefore been experimentally demonstrated that the accumulation of vibroseismic signals for deep seismic sounding procedures is feasible. It was possible to measure the absolute values of the amplitudes of primary oscillations and the mean square level of microseismic noise. It appears that a level of the useful signal of about 10^{-2} is the maximum with respect to the possibility of its discrimination in accumulation time intervals of practical value for deep seismic sounding. Figures 1, tables 1; references 10: 9 Russian, 1 Western.
[JPRS]

UDC 550.344

FOCUSING PROPERTIES OF SEISMOHOLOGRAPHIC IMAGES

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 4, Apr 82
(manuscript received 19 Jun 81) pp 81-88

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[Abstract] The focusing properties of seismoholographic transformations were investigated. For an object with a cylindrical reflection surface a study was

made of the conditions for maximum image brightness in the case of D- and M-transformation, regulated directional reception, and also as a result of summation in the common shot point method. The author has derived an expression for the apparent seismic velocity at which such a maximum exists. In the case of a D-transformation this apparent velocity coincides with the true value only for a point object, whereas for a plane object it is less by a factor of $\sqrt{2}$. It is noted that for the mentioned types of transformations the appearance of spurious images is possible; these spurious images can be excluded by the introduction of additional observation systems. It is shown that the properties of seismoholographic transformations can be conveniently examined in a two-dimensional variant for a cylindrical test object. The execution of these transformations on a computer makes it possible, depending on the ratio of the computed and true values of the velocities of seismic waves, either to obtain the true image of the object or focus it a point. With a finite wavelength the focused image will assume the form of a spot approximately with the dimensions of the wavelength; this can be effective when discriminating the useful signal from noise, especially when using additional transformation for restoration of the true form of the record. Figures 5; references 9: 8 Russian, 1 Western.
[188-5303]

UDC 530.834

EVALUATING KINEMATIC PARAMETERS OF SEISMIC WAVES BY FOCUSING METHOD

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 4, Apr 82
(manuscript received 18 Jun 81) pp 71-80

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[Abstract] This article is the first in a series of publications devoted to solution of the inverse kinematic problem, the problem of restoration of stratum (interval) velocities and the geometry of the reflecting boundaries with the use of a reversed continuation of seismic wave fields. Solution of inverse kinematic problems involves measurement of such kinematic parameters of waves as the first and second derivatives of the eiconal. This measurement is the most critical link in the kinematic interpretation process and to a considerable degree governs the accuracy of the final result. As indicated in the article, there are special fields which can be used in evaluating the parameters necessary for solution of the inverse kinematic problem. In this case the reversed continuation of the field is not regarded as a result of interpretation, but as an intermediate system of criteria used subsequently for reconstructing a velocity model of the medium and the deep section. In this article the evaluation of the kinematic parameters necessary for reconstructing the velocity model is based on focusing of the reversed continuation. Specifically, it is shown that if the reversed continuation of the seismic wave field is constructed, selecting different velocity values v_c in the lower half-space, with some values $v_c = v_{ex}$ the waves identifiable as the image of reflecting objects will have a maximum amplitude. In a general

case the extremal velocity v_{ex} does not coincide with the true (or effective) velocity in the medium. Formulas are derived which relate the extremal velocity to the derivatives of the eikonal of the reflected wave and also to the parameters. It is shown that these formulas can be used in solving inverse kinematic problems. Figures 3; references 7: 6 Russian, 1 Western. [188-5303]

UDC 550.346

EFFECT OF HIGH-VOLTAGE POLARIZATION ON ROCK RESISTIVITY DURING SEISMICALLY ACTIVE PERIOD

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 267, No 4, Dec 82
(manuscript received 28 Jun 82) pp 822-824

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[Abstract] In earlier studies it was demonstrated that a considerable decrease in resistivity occurs in the epicentral region of an earthquake 2-3 months before a seismic event. This change in resistivity is usually attributed to a redistribution of fluid or its microdiffusion from pores. However, another possible cause of resistivity changes may be high-voltage polarization, in exploratory geophysics called induced polarization. The latter arises due to different physicochemical processes at the time of imparting of a d-c voltage and increases with time, tending to a constant value. This results in a decrease in current strength and an increase in the registered resistivity. The degree of high-voltage polarization is dependent on the petrophysical properties of the rocks and a number of external factors: imparted voltage, duration of imparting of voltage, temperature and pressure. With an increase in temperature the high-voltage polarization decreases and with t ≥ 300°C is virtually absent if there are no polymorphous transformations or other physicochemical processes. Pressure also exerts a considerable influence on the high-voltage polarization of mineral matter. The high-voltage polarization of sandstones, shales, diabases and other rocks decreases from several to 50% with an increase in pressure from $5 \cdot 10^{-3}$ to 10^{-1} GPa. However, in the case of uniaxial compression of sedimentary rocks with an incomplete saturation with an electrolyte there is a different picture--a increase in resistivity with an increase in pressure. Regardless of the loading method and the degree of moisture saturation, with an increase in electric field frequency the intensity of the change in resistivity with pressure attenuates. These phenomena help to explain baylike resistivity changes during seismically active periods. In order to carry out effective electric prediction of earthquakes it is possible to use a d-c current or current pulses of the maximum possible duration and amplitude. The nature of the change in resistivity can serve not only as a prognostic earthquake indicator, but also may contain additional information concerning the redistribution of stresses. The combining of dipole sounding, sounding by the formation of an artificial field and the induced polarization method, with allowance

for regional geology, makes it possible to obtain definite volume-differentiated information on the nature of change of the field of mechanical stresses before and after a seismic event. Figures 3; references 7: 6 Russian, 1 Western.
[48-5303]

UDC 550.341

CRUSTAL STRENGTH AND SEISMIC EFFECTIVENESS OF EARTHQUAKE FOCI

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 8, Aug 82
(manuscript received 19 Jun 81) pp 114-122

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[Abstract] It is demonstrated by the author on the basis of a critical review of the Soviet and foreign literature (52 sources are cited) that the inconsistencies in estimates of crustal strength can be resolved and it is also possible to clarify the problem of the seismic effectiveness of an earthquake focus. The author has refined the relationships between seismic moment and magnitude, energy, dimensions of fractures and some other earthquake focus parameters. On this basis it is demonstrated that the ratio of seismic energy to seismic moment is not dependent on earthquake magnitude, being about 10^{-2}. The breaking stresses are also not dependent on earthquake magnitude and are characterized by an average value $3 \cdot 10^3$ and 8 bar. On the basis of these and other conclusions it is shown that crustal strength should not be less than $3 \cdot 10^3$ bar and the seismic effectiveness of an earthquake focus is not less than 0.5. The author contends that it is unquestionable that the crust has a rather high (more than 1000 bar) strength, agreeing well with estimates of the shearing stresses constantly operative in the crust and the results of strength tests of rock samples. There is only a small jump in stresses at the time of an earthquake not exceeding an average of 1% of the stress operative at its focus. This means that in the focal zones the medium is always in a strongly deformed, near-critical state, regardless of when an earthquake occurred here or of what magnitude it might have been. Also noteworthy is the high seismic effectiveness (efficiency) value, indicative of relatively low energy releases even at the earthquake focus itself. Figures 3; references 52: 27 Russian, 25 Western.
[48-5303]

UDC 550.34

WAVE FIELD NEAR FAULT AND EVALUATION OF SOURCE PARAMETERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 3, Jan 83
(manuscript received 22 Aug 82) pp 579-583

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[Abstract] During recent years there has been increased interest in observations of strong movements of the ground near earthquake foci. Systematic observations along these lines were made in the near zone of strong earthquakes by an epicentral seismological expedition of the Institute of Physics of Earth. Oscillations were registered at distances of 5-50 km from the epicenter, at the registry point being sensed with an intensity from 3 to [illegible]-10 scale units. The true movement, reconstructed on the basis of these records, demonstrates that in the wave field of the near zone, in addition to the constantly observed longitudinal and transverse waves, there are three other types of disturbances. Two of these, "stepped" P- and S-deviations and the Gamburtsev "Laplacian" disturbance rapidly attenuate with distance and can be observed only at the stations closest to the focus (with hypocentral distances 10-20 km). At distances greater than 40 km the Laplacian disturbance is not observed for earthquakes with $M \leqslant 5.2$. The results make it possible to give a clear physical interpretation of the theoretical Haskell model in which the earthquake focus is stipulated in the form of a dislocation in a homogeneous isotropic unbounded elastic medium. As an example the article examines the Haskell formula for the displacement component directed along the fault propagation for a stipulated dislocation on a given surface. Comparison of computations using the Haskell formula for a dislocation source with real records reveals that each term of the Haskell formula corresponds to a definite type of real movement in the near zone. For example, the first term corresponds to the Laplacian disturbance and is operative from the time of arrival of the longitudinal wave to the end of the transverse wave effect. The second and third terms correspond to the "stepped" displacements propagating with the velocities of the P- and S-waves. This coincidence indicates a good correspondence between the theoretical model and the real process at the earthquake focus. Such an interpretation of the theoretical solution for the wave field of the epicentral zone was made for the first time. The Laplacian disturbance and the "stepped" P- and S-deviations are responsible for the transfer of the resultant residual displacement of the medium. In the near zone the instantaneous parameters of this displacement can play an important role in the formation of destructive seismic effects on ground and structures. Comparison of the experimental and theoretically computed displacements in the vertical component makes it possible to estimate the amplitude of the movement at the focus. These and other considerations made it possible to propose formulas for computing the seismic moment of an earthquake in the intermediate zone on the basis of these components of movement. Figures 3; references 13: 10 Russian, 3 Western.

[illegible]

UDC 550.347.93

SEISMIC ANISOTROPY OF MANTLE TRANSITION ZONE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 3, Jan 83
(manuscript received 7 Jul 82) pp 575-579

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[Abstract] In seismic fields in order to separate the effects of azimuthal anisotropy and horizontal inhomogeneity it is necessary to make observations in a network of profiles intersecting the same region in many directions. However, this approach, which is effective in studying anisotropy of the crust or top of the mantle, loses its practical value at greater depths. Accordingly, the authors have developed a new method for investigating azimuthal anisotropy of the deep layers. In this approach use is made of exchange waves of distant earthquakes transformed from P waves into S waves on deep discontinuities. In a horizontally homogeneous isotropic medium the P wave is transformed into a transverse SV wave, polarized rigorously in the vertical plane passing through the source and detector. In an anisotropic or horizontally inhomogeneous medium the exchange wave can have the component SH perpendicular to the vertical plane containing the component SV. The problem of investigating the anisotropy of great depths can therefore be divided into two parts: discrimination of the component of SH exchange waves of distant earthquakes and interpretation of the discriminated phases in terms of anisotropy and horizontal inhomogeneity. The SH component of the PS wave was discriminated using observations at 22 three-component long-period seismograph stations in southern Norway. The data employed were three-component digital records of 20 distant earthquakes with foci in different azimuths and with different epicentral distances. The different steps involved in the analysis are outlined. It is shown that for separating the anisotropy and horizontal inhomogeneity effects it is necessary to carry out a harmonic analysis of the observed SH component as a function of source azimuth. According to modern concepts, in the earth's deep layers there are convective flows affecting the entire mantle or only its upper part. In the second case at the bottom of the upper mantle there can be a horizontal flow of matter. This flow could orient the crystals of the anisotropic minerals and form an anisotropic layer at the bottom of the upper mantle explaining the results of this study. Figures 4, tables 1; 8 references: 3 Russian, 5 Western.
[[illegible]]

UDC 550.822:622.241

MULTISIDED PROGRAM FOR DEEP STUDY OF EARTH

Moscow SOVETSKAYA GEOLOGIYA in Russian No 9, Sep 82 pp 3-12

KOZLOVSKIY, Ye. A., USSR minister of geology, chairman Interdepartmental Scientific Council on "Study of Earth's Deep Layers and Superdeep Drilling"

[Abstract] The article begins with a summarization of the most important results of study of deep structure of the earth in the USSR during the period 1976-1980 with emphasis on multisided geological and geophysical studies of the most important regions and the drilling of superdeep holes. However, the main purpose of the author is to outline the principal tasks in study of deep structure during 1981-1985 and in the period up to 1990. The program is intended for solving problems involved in studying deep structure of the crust by deep and superdeep holes and geological-geophysical methods and determination of the prospects for finding petroleum and gas and mineral ores in the principal regions of the country. An important aspect of the program will be regional geological and geophysical investigations whose purpose will be formulation of standard models of the tectonosphere for regions with different geodynamic conditions for the principal petroleum, gas and ore regions of the country. The need is recognized for a qualitatively new approach to the planning and implementation of such work and this can be achieved only by creating a unified system of regional study of the crust and upper mantle over the entire territory of the USSR. The basis for such a system will be a network of mutually tied-in geophysical profiles resting on deep and superdeep reference boreholes. So-called prognostic geophysical polygons will also be included in the system. The basic net will serve as a framework in which more detailed investigations will be made. The use of data from space geological and aerogeophysical surveys will make possible creation of three-dimensional geological-geophysical models of different scales for the country as a whole. Figure 1 in the text is a map of the proposed deep and superdeep holes and deep seismic profiles. All this work will facilitate medium- and large-scale prediction and exploration of mineral deposits. Provision is being made for a considerable expansion of the volumes of deep and superdeep drilling. Work will continue on drilling of the Kola and Saatly holes. Work will begin on the drilling of three other superdeep (12-15 km) holes. During the 11th Five-Year Plan work will be initiated on the drilling of 6 deep holes, three in petroleum regions and three in ore regions. The Kola superdeep hole, for example, during the 11th Five-Year Plan should reach a depth of 13,000 m; geophysical investigations will be made in the Saatly hole to a depth of 11,000 km. (Important details are given concerning the planned deep and superdeep holes.) This entire program is dependent on considerable advances in equipment and methods of geophysical research. (The different instruments and types of apparatus scheduled for development or improvement are discussed in considerable detail.) The planned system for investigating deep structure of the USSR is represented in a block diagram. The program, at a new qualitative level, will make possible a study of the structure and history of development of different tectonic zones--shields and ancient platforms, folded zones of different age, marginal seas of the continents and island arcs, including study of recent

tectonic movements. It will be possible to construct more reliable petrological models of the lithosphere for different types of geological structures having different mineragenetic features. It will also be possible to formulate a unified methodological basis for constructing geological-geophysical maps and sections. Figures 2.
[41-5303]

UDC 550.34.016

PROBLEMS IN STUDY OF SEISMOTECTONIC DEFORMATION OF ROCK MASSES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 82 (manuscript received 25 Feb 82) pp 105-110

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[Abstract] The article describes formulation of the problem of study of the seismotectonic deformation process in the territory of Central Asia and Kazakhstan. The need for such a formulation is dictated by successes recently attained in studying the focal mechanisms of seismic tremors. Past work on analysis of the focal mechanisms of strong earthquakes (M > 5) in Central Asia has revealed a definite stability in the orientation of the compression axes in a near-meridional direction. Concepts on the geological structure and tectonics of Central Asia served as the basis for dividing the investigated region into a number of zones (mapped in Fig. 2). Within the limits of the defined zones there is some quasihomogeneity of geological-tectonic conditions which to a certain degree justified the assumption that there is a quasiuniformity of seismotectonic deformation in each of the zones. In this article attention is given only to the spatial direction of the rate of seismotectonic deformation, describable by the mean mechanism matrix discussed in detail by S. L. Yunga in IZV. AN SSSR: FIZIKA ZEMLI, No 10, pp 14-23, 1979. The results of computations of seismotectonic deformation for the 16 defined zones are given in a table. Data for 254 earthquakes were used. The positions of the main axes and nodal surfaces of the mean mechanisms are shown in Fig. 2 in a stereographic projection onto the upper hemisphere. The figure shows that the considered territory is in a state of predominance of near-horizontal compression in a submeridional direction. This result agrees with earlier concepts on the nature of the studied focal mechanisms of strong earthquakes. There is a definite spatial stability in the distribution of zones with approximately identical directions of maximum compression. Figures 2; tables 1; references: 32 Russian.
[41-5303]

UDC 550.348.098.64

STATISTICAL ANALYSIS OF EUROPEAN EARTHQUAKES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 82 (manuscript received 30 Apr 82) pp 68-73

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[Abstract] A study was made of the statistical properties of seismicity in the European region; particular attention is given to the general law of frequency of recurrence of seismic events and the statistics of extremal values. The theory of extremal values makes it possible to obtain useful information on the period of recurrence of earthquakes of different magnitude or the probability with which this magnitude can be exceeded in the future. It was found that the period of recurrence of major events according to a normal extremal distribution exceeds the period of recurrence according to a double extremal exponential distribution (for evaluating danger the exponential form is preferable); the periods of recurrence, evaluated using the third asymptotic distribution, exceed the periods obtained from the first asymptotic distribution (which gives a lesser danger evaluation) and there is better correspondence to the observed data. On the basis of these and other considerations it was possible to propose a new statistical model of the occurrence of earthquakes. It is shown that the most important characteristic of the series of earthquakes which cannot be described by a Poisson distribution is the tendency of earthquakes to grouping; the Poisson distribution is based on the assumption that the probability of one event remains constant, something which is rarely observed. Use was made of a negative binomial distribution determining the probability of appearance of multiple events. A negative binomial distribution can be obtained as a generalization of a Poisson distribution. A negative binomial distribution corresponds to observations better than a Poisson distribution and allows the appearance of more than one event in a unit time. The new model describes the appearance of shallow-focus earthquakes of low and moderate magnitude in Europe better than a simple Poisson process. Figures 4; references 16: 1 Russian, 15 Western. [22-5303]

UDC 550.348

SPATIAL PATTERNS IN AFTERSHOCK DEFORMATION OF STRONG EARTHQUAKE FOCAL REGION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 82 (manuscript received 5 Feb 82) pp 62-67

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[Abstract] Little information has been available on deformational processes directly in earthquake focal regions. However, data collected in recent years

have made possible the study of such deformations in the course of the aftershock process. In this article the patterns of the aftershock deformation of the focal region of a strong earthquake are examined in the example of aftershocks of the Markansuysk earthquake of 11 August 1974 in the northern Pamirs. The elementary volumes for which the mean values of the tensor of deformations were determined had dimensions in latitude and longitude equal to 0.2° and a depth of 30 km. The six components of the tensor of deformations in a geographical coordinate system were computed. The components of the tensor of deformations of the aftershock process and the components of the tensor of deformations of the main tremor were compared. On the basis of the distribution of components of the tensor of deformations of the aftershock process it was possible to define the focal region of the main event and ascertain the dimensions of the Markansuysk earthquake fault. The joint analysis of these two types of tensors revealed that the aftershock deformations of the focal region have a quite complex character, not at all fitting in with the mechanism of aftershock inheritance or within the framework of the mechanism of aftershock unloading. Within the focal zone of this earthquake as a result of aftershock activity there was considerable (up to 10 cm) subsidence of the earth's crust. Figures 3, tables 1; references 13: 12 Russian, 1 Western. [40-1303]

UDC 550.34.013.4

MODEL INVESTIGATIONS OF FIELD OF ELASTIC WAVES AND RESIDUAL DEFORMATIONS CAUSED BY SHEAR FAULT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 83 (manuscript received 18 Mar 82) pp 48-56

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[Abstract] Proceeding on the basis of the Yu. V. Riznichenko thesis that the main problem of earthquake physics is study of the nature of an earthquake focus and the totality of foci forming the seismic regime, the authors study the nature of the focus of a single earthquake and endeavor to relate the process of a shear displacement along a fissure simulating a buried fault or fault emerging at the surface to residual deformations at the free surface of the model. This constitutes a first step in using in model investigations of an earthquake focus of those ideas advanced by Yu. V. Riznichenko on an extended focus and the need for a joint study of the seismic and tectonic flow of rock masses. The preparation of the model and the experimental technique were described in an earlier study by the authors (IZV. AN SSSR: FIZIKA ZEMLI, No 11, pp 13-27, 1979). A plexiglas plate in which there is a predetermined fissure with closed sides is subjected to uniaxial compression. As soon as the shearing stresses on the fissure become adequate for overcoming the frictional force between its sides there is a shearing of the sides relative to one another. It usually begins as a slow slippage against whose background there is a series of rapid displacements of much greater amplitude.

The data obtained in the described model experiment for studying the radiation of elastic waves by a shear fault make it possible to give a probable explanation of the observed facts of a nonuniform distribution of the "+" and "-" signs in the first arrivals of waves from earthquakes and the difference in amplitudes of the compressional and dilatational waves. For continental earthquakes the magnitudes determined from the compressional waves are greater than the magnitudes determined from the dilatational waves. For earthquakes in the Benioff focal zone, on the other hand, the magnitudes determined from the dilatational waves are greater. The earthquakes in the Benioff zone occur primarily due to interaction of a plunging oceanic plate and a continental plate. Due to the relative movement of the plates the strength of the rock material between them is evidently less than in continental regions. Therefore, at the foci of interplate earthquakes the velocity of propagation of a fault will be lower and the radiated energy will be less than at the foci of continental earthquakes. Accordingly, the dimensions of faults at the foci of earthquakes in the Benioff zone can be greater than their dimensions at the foci of continental earthquakes with the very same magnitude. Figures 3; references 7: 5 Russian, 2 Western.
[illegible]

UDC 550.834

METHOD FOR DETERMINING ABSORPTION FROM REFRACTED WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 82 (manuscript received 6 Apr 81) pp 31-41

[illegible], [illegible] and [illegible], T. I., Geology Faculty, Moscow State University

[Abstract] Many methods exist for determining seismic wave absorption and this parameter is used very frequently in the interpretation of reflected waves. At present there are really no methods for determining absorption for refracted waves although they predominate in the formation of the wave pattern in the first arrivals. For this reason the authors propose a method for determining the absorption coefficient applicable for both one- and two-dimensionally inhomogeneous models of media. First the authors examine a case when velocity and absorption in the medium are dependent only on depth. Then a study is made of a medium nonuniform in both vertical and horizontal directions and systems of travel-time curves and systems of amplitude curves of refracted waves are obtained. In this study a major role is played by preliminary solution of the direct problem for a velocity model of the medium in which the absorption is determined. A solution of this problem is needed in order to compute the lengths of the ray segments in the layers which enter into the main formulas of the method and computation of geometrical divergence for the purpose of subsequent introduction of corrections into the amplitude curves. The step-by-step integration of a system of six differential equations is basic in the algorithm for solution of the direct problem. Different cases when application of the proposed method for determining absorption requires special preliminary processing for both horizontally

uniform and two-dimensionally inhomogeneous media are discussed. Application of the method is illustrated in relation to experimental data obtained by the refracted waves method in the southern part of the Baltic Sea; good results were obtained. It is shown that the final result is influenced by errors in determining the velocity model, but if the errors are not too great the overall nature of the distribution of absorption in the medium is reconstructed reliably. Figures 6, tables 1; references 7: [illegible] Russian, [illegible] Western. [illegible]

UDC 550.34[illegible]

SCATTERING AND ABSORPTION OF LONGITUDINAL SEISMIC WAVES IN EARTH'S CRUST

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 10, Oct 85 (manuscript received 9 Apr 85) pp 20-3[illegible]

[illegible], NIKOLAYEV, A. V. and [illegible], [illegible] Yu., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] The authors develop a new approach to evaluation of the scattering properties of real media based on study of spatial fluctuations of the wave field of the first longitudinal waves. Such an approach has considerable advantages because the spatial fluctuations of amplitude and phase of the first P wave are a direct consequence of scattering on local velocity inhomogeneities of the medium. With use of the characteristics of fluctuations of the wave field of the first waves a possibility is afforded for an independent evaluation of the scattering coefficients. The authors here develop and generalize some results of study of the effects of scattering of seismic waves in the frequency range 1.5-20 Hz in the crystalline crust and upper mantle. The following are considered in detail: seismic scattering coefficient; relationship between total and seismic scattering coefficient; possibilities for evaluating total scattering coefficient; relationship between coefficients of attenuation and scattering of longitudinal waves. The analysis reveals that the effects of scattering on local velocity inhomogeneities, if not playing the dominant role, at least play a role equal to absorption in the total attenuation of the energy of P waves with distance. This finding fundamentally changes existing concepts concerning the unimportance of the role of scattering effects in the overall balance of energy in the propagation of P waves in real media. The same conclusions on the role of scattering effects were obtained in investigation of the characteristics of scattering on the basis of the seismic coda. The developed method for evaluating scattering coefficients, based on study of spatial fluctuations of the wave field of the first P waves, makes it possible to obtain evaluations of the scattering coefficients independent of the absorption characteristics. This is its advantage in comparison with methods for studying the scattering properties of the medium on the basis of the characteristics of the seismic coda. The proposed methods do not make it possible to take into account the effects of exchange and multiple scattering and therefore are suitable mainly for studying the effects of scattering of the first longitudinal waves. Figures 4; references 17: 15 Russian, 2 Western.
[illegible]

UDC 550.360:550.341

TEMPERATURE VARIATIONS IN SEISMICALLY ACTIVE REGION ACCORDING TO OBSERVATIONS IN HYDROGEOLOGICAL BOREHOLES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 9, Sep 82 (manuscript received 15 Jan 82) pp 71-75

ISMAIL-ZADE, T. A., LYUBIMOVA, Ye. A., MUKHTAROV, A. Sh., SULTANOVA, Z. Z. and PIMENOV, V. V., "Geofizika" Scientific Center, Azerbaijan Academy of Sciences; Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] Only a few observations have been made of temperature variations prior to an earthquake. The authors have made a preliminary analysis of the results of geothermal observations in boreholes in the seismically active region Sheki, Azerbaijan, during 1979-1981. This is a region intersected by tectonic dislocations running parallel to the axis of the Greater Caucasus. The region is at the intersection of longitudinal tectonic dislocations and a zone of transverse dislocations. In the Sheki region it is assumed that the earthquake foci are situated for the most part at depths of 3-5 km. During the period 1979-1981 geothermal investigations were made in two hydrogeological boreholes ("Bilidzhik" and "Gyrkhbulag"); three heat sensors were inserted in the first of these holes at different depths and one was inserted in the second. A figure shows the location of earthquake epicenters for events occurring in the neighborhood of Sheki during this period. Figure 2 shows examples of temperature variations. The temporal variations of temperature were compared with earthquakes of energy class 7-12 with epicentral distances no greater than 100 km. The temperature variations in this area are possibly related to the variable fissuring of the crust and mobility of fluids during seismic activation. There is a high degree of fissuring so that there can be an intensive exchange of heat and mass as a result of the filtering of fluids through the fissures. These temperature variations in some cases appear to be an "alarm" prior to a seismic tremor. The temperature records show that after an "alarm" represented by temperature variations of 0.3-0.7°C within 15-17 days there will be 2-7 tremors of energy class 7-12 in the stipulated radius of 100 km. It appears that there may be two times of appearance of seismogeothermal "alarms" before tremors of energy class 7-12: [illegible] and 3-35 days. Figures 2; references 16: 14 Russian, 2 Western.
[illegible]

UDC 550.341

TEMPORAL STABILITY OF FORECAST OF SITES OF STRONG EARTHQUAKES. II. EASTERN PART OF CENTRAL ASIA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 9, Sep 82 (manuscript received 25 Jun 81) pp 30-38

GVISHIANI, A. D. and GURVICH, V. A., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] The requirement of temporal stability for predicting the sites of strong earthquakes was examined in an earlier article by the authors (IZV. AN SSSR: FIZIKA ZEMLI, No 8, pp 13-19, 1982). This article constitutes an integral part of the overall line of investigation. A study was made of a seismic region. An earthquake is considered strong if its magnitude exceeds the threshold M_0, selected in advance for this region. It is postulated that the epicenters of strong earthquakes cannot be situated in the entire area of the region, but only within the limits of disjunctive nodes, and only at certain of these nodes. The problem arises of discriminating these seismically dangerous nodes. The problem is solved by the image recognition method. In a case when the morphostructural scheme of the region determining the precise boundaries of the disjunctive nodes is unknown it is possible to consider some neighborhood of the intersections of lineaments, or if the pattern of lineaments is unknown, the entire region can be broken down into approximately equal sectors. In this undertaking the breakdown of image objects varies with time. This makes it possible to impose a requirement of temporal stability on the prediction and thus considerably narrow the range of classifications which can serve for predictive purposes. Within the framework of the general image recognition theory it is possible to determine a class of dynamic recognition problems whose distinguishing characteristic is the dependence of the classification of objects on time. A definition of a stable prediction is given for the dynamic problem and a stability test is introduced for a prediction made with the recognition algorithm. All this is used in demonstrating the stability of prediction of sites of strong earthquakes in the central part of Central Asia where the epicenters of earthquakes with $M \geq 6.5$ can be situated. References: 6 Russian.
[illegible]

UDC [illegible]

[illegible] OSCILLATIONS OF EARTH'S SURFACE AS FUNCTION OF LOCAL CONDITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 9, Sep 82 (manuscript received 17 Sep 80) pp 19-29

[illegible], A. A., [illegible], S. V. and [illegible], A. N., Institute of Physics of Earth, USSR Academy of Sciences; Institute of Mechanical Problems

[Abstract] The author gives a review of theoretical studies relating to evaluation of movement of the earth's surface under different local conditions, [illegible] the structure of the upper strata, the mechanical properties

of the layers forming it, surface relief and relief of subsurface discontinuities. Problems along these lines have been dealth with in the literature for extremely simplified, schematic situations, whereas real, specific conditions are complex and diversified. Here the problem is examined in 6 sections: elastic layer on an elastic half-space; multilayer medium; inhomogeneous layer; inelastic medium with allowance for absorption; elastico-plastic medium; influence of relief. In each of these sections the authors attempt to point out the most important studies which have been made, the advances and deficiencies in the particular line of research. The review itself is acknowledged to have inadequacies: for example, it contains virtually no quantitative characteristics reflecting the influence of local conditions on the intensity and spectrum of surface oscillations. The purpose of the review is a clarification of the physical aspects of this problem to promote further research in this area. Figures 10; references 68: 22 Russian, 46 Western.
[illegible]

UDC 550.311

MODEL OF UPPER LAYERS OF EARTH'S CRUST

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 9, Sep 82 (manuscript received 3 Dec 81) pp 3-9

SADOVSKIY, M. A., DENSHCHIKOV, V. A., KONDRAT'YEV, V. N., ROMASHOV, A. N. and [illegible], V. M., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] There is a multilevel or multistage block structure of the earth's crust. The upper relatively small blocks are situated on lower larger blocks and these are situated on still larger blocks whose size can be of a planetary scale. Here an attempt is made to explain some processes transpiring in the crust using a model taking into account this block structure and the presence of excess stresses in the rocks. The article examines the behavior of a two-layer model in which the lower layer is continuous and subject to some active deformation, whereas the upper layer is broken into individual blocks and is passive, receiving energy from the lower layer due to deformation of the base itself. Two cases are considered: 1) the lower layer experiences dilatation; 2) the lower layer is compressed. The proposed model makes possible a qualitative explanation of some features of the stressed state in the upper layers of the crust. It follows that near the earth's surface compressional stresses can appear under the condition that in the deeper layers even excess dilatational stresses may exist. The proposed model is in good agreement with the known fact of a considerable horizontal inhomogeneity of excess compressional stresses. At points in the rock mass situated at relatively short distances from one another the excess stresses can differ substantially in both magnitude and sign (compressional stresses can undergo transition into dilatational stresses). Near faults stresses increase in the direction of the boundary of a block, but sometimes the maximum of the stresses is at its middle part. Qualitatively all these features of stressed states can be explained by the two-layer model. The data presented in the article on the nature of destruction of the upper layer

help in explaining some features of fault formation in the upper layers. The destruction of the upper layer is a regular process in which the appearance of successive faults is predetermined to a considerable degree by preceding fissures. It is apparent that the structure of the fields of excess stresses in the upper layers and the regularity of formation of fault systems in them are caused by some single mechanism explainable within the framework of this two-layer model. Figures 3; references: 12 Russian.
[22-5303]

UDC 550.8

DEVELOPING APPLIED GEOPHYSICAL RESEARCH IN UKRAINE

KIEV GEOFIZICHESKIY ZHURNAL in Russian Vol 4, No 4, Jul-Aug 82
(manuscript received 16 Feb 82) pp 81-93

KIVSHIK, N. K. and CHIRVINSKAYA, M. V., "Ukrgeofizika" Production Association

[Abstract] The geophysical service in the Ukraine marked its 50th anniversary in 1980 and this article is a review of its activities and accomplishments during that period. Different sections are devoted to field geophysical work, electric prospecting, seismic prospecting, search for mineral resources and special studies. The results are broken down into four stages: 1930-1948; 1949-1960; 1961-1970; 1971-1980. In the most recent stage the emphasis has been on an increase in the quality and reliability of study of deep layers of the sedimentary cover. This has been achieved by a further improvement in work methods and techniques. This has made it possible to detect new, earlier hidden structures. In some areas new data have been obtained on the geological structure of Lower Cretaceous deposits and significant corrections have been made to earlier materials, although it still has not been possible to obtain a reliable record at great depths. New data have made it possible to supplement tectonic and composite structural maps and plot them at larger scales. The structural map of the basement surface of the Donetsk coal basin has been made considerably more detailed. Important work has been done on generalization of data on structure of the earth's crust. Equally important results have been obtained by carrying out geophysical observations in boreholes, revealing many characteristics of the geological section. Correlation of sections has made it possible to define breaks in sedimentation, to trace them in area and time, to analyze changes in thickness and lithofacies composition. Such data have been used extensively in compiling tectonic maps. Until the mid-1960's data from geophysical observations in boreholes had been used almost exclusively for defining and studying productive horizons. Now such data are being employed successfully in the breakdown and correlation of the geological section, in detecting collectors, estimating their fluid content and determining the parameters of strata. In addition, such data are now used in monitoring the technical state of boreholes and the rock mass outside the column. For the first time in the USSR geophysical investigations were made in superdeep holes--Shevchenkovo 1 (7520 m), Sinevidnoye (7000 m), Poltavskaya (6500 m). During the last 10-15 years the principal computation parameters used for estimating petroleum and gas reserves have been determined

using data from geophysical investigations in boreholes. In coal logging the standard complex of measurements is supplemented by a study of ash content; acoustic logging is used in improving the physicomechanical properties of the country rock and ascertaining fissuring intervals. An electric method for correlating strata has been introduced. Much new information has been obtained for solving problems in regional tectonics and in detecting different structural forms favorable for the accumulation of fluids. All these investigations, in addition to the many others made during the reviewed periods, have been extremely productive from the scientific and economic points of view.

[illegible]

UDC 550.382.7+551.2

MODERN 'PLATE' TECTONICS AND ITS POSSIBLE ALTERNATIVE

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 4, No 4, Jul-Aug 82 (manuscript received 1 Mar 82) pp 34-[illegible]

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[Abstract] It is the author's contention that the plate tectonics hypothesis cannot be further developed or improved; the fundamental postulates at the basis of this hypothesis are erroneous. One of the principal assumptions of global tectonics is that there is a spreading of the ocean floor and at an exceptionally high rate. The principal inadequacy of the concept of spreading of the ocean floor is that it is in direct contradiction with the actualism principle on which theoretical geology, as before, is based. (The author does not deny the existence of dilatational tectonic structures in the Atlantic and other oceans.) The article reviews the empirical data and tests these data against the arguments of the adherents of the new global tectonics. It is shown that all the important structural elements of the Atlantic Ocean were formed in the Early Mesozoic and developed as an integral gigantic geological structure, not experiencing the major dilatation postulated by plate tectonists. All three zones of deep faults were situated approximately where they exist now. All newly discovered facts can be explained without recourse to the hypothesis of a spreading ocean floor. Taking everything into account, there is clear evidence of an exceptional antiquity of the present-day configurations of the continents, especially the systems of deep faults of the continents bordering the Atlantic tectonic structure. The hypotheses of a spreading ocean floor and the new global tectonics, based on spurious premises, have held back the progress of science for 10-15 years. Figures [illegible]; references 26: 10 Russian, 16 Western.

[illegible]

UDC 550.334+[illegible]

PERIODIC VARIATIONS OF SEISMIC WAVE PARAMETERS DURING PROBING OF LITHOSPHERE BY POWERFUL SHOTS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 6, Oct 82
(manuscript received 21 Apr 82) pp 1349-1353

GAMBURTSEVA, N. G., LYUKE, Ye. I., NIKOLAYEVSKIY, V. N., ORESHIN, S. I., PASECHNIK, I. P., PEREGONTSEVA, V. Ye. and RUBINSHTEYN, Kh. D., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] The article gives the results of a study of variations of the dynamic parameters of seismic waves with time made over the course of 12-14 years in some seismic regions of Kirgizia and aseismic regions on the Russian and Kazakhstan Platforms in the range of epicentral distances 100-2500 km by the method of probing with powerful shots. The dynamic parameters used were the ratios of the maximum amplitudes of longitudinal and transverse waves of different classes. The ratio of amplitudes is a more stable parameter than the amplitudes themselves because it is not dependent on magnitude and other conditions at the source and characterizes the state of the medium on the wave propagation path. The following waves were considered: P_g, S_g and L_g, transmitted through the granite layer above the Conrad discontinuity; P^x, S^x--through the entire crust; P_n, S_n, P_M^{refl}, S_M^{refl} (refracted and supercritically reflected at the Moho)--through the crust and top of the mantle; P, PP, S, SS--through the crust and earth's upper mantle. There was a combining of parameters of two types: parameters "of the same type"--the ratios of amplitudes of longitudinal and transverse waves traveling identical paths, S/P, S_g/P_g, S^x/P^x, etc. and parameters "of different types"--the ratios of the amplitudes of waves traveling different paths--S/P^x, S/P_g, P/P_g, etc. The changes in the dynamic parameters with time are thoroughly analyzed. A periodicity is manifested which intensifies with an increase in the depth of sounding and is most clearly expressed for parameters associated with the lower part of the crust and upper mantle. The principal result of the study was the revelation of a periodicity of 5-7 years in the time sequence of dynamic parameters measured from the records of stations situated in both seismically active and aseismic regions. These changes in seismic parameters may be caused by dilatancy effects--by the opening or closing of the great many fissures present in the crust. The dilatancy changes take in regions of the lithosphere with a horizontal scale of thousands of kilometers and are not identical for different layers of the crust. Since dilatancy fissure formation is determined by the operation of tectonic forces the revealed periodicity means that there are tectonic stress waves in both seismic and quiet regions. Figures 4, tables 1; references 4: 3 Russian, 1 Western. [illegible]

UDC 537.226+550.344.093

ELECTRIC PHENOMENA ACCOMPANYING ROCK SLIPPAGE UNDER INFLUENCE OF HIGH HYDROSTATIC PRESSURE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 6, Oct 82
(manuscript received 16 Mar 82) pp 1347-1349

[illegible], [illegible] Kh., BYERLEE, J. D. and KUKSENKO, V. S., Seismology Institute, Uzbek Academy of Sciences, Tashkent; Physical-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Static electric fields appear with the loading of rock samples in the laboratory. The article describes the appearance of electric fields in the case of a displacement simulating the movement of the earth's crust along an existing fault (the work was carried out in the laboratory of J. D. Byerlee, US Geological Survey). The text is accompanied by a diagram of the high-pressure chamber employed. A cylindrical sample of granite from the San Andreas fault with a diameter of 3 cm and a length of 6 cm was cut at an angle of [illegible]. The sample was placed in the chamber and subjected to uniaxial compression. The control of the chamber, loading of the sample and registry of the load and displacement were accomplished by computer. During measurements a time-constant signal could be registered only when there was a constant change in electric potential. The experiment began with the imparting of hydrostatic pressure, maintained constant throughout the experiment, followed by uniaxial loading. The onset of smooth slippage is accompanied by a jumplike appearance of electric potential. Shortly before displacement there is a sharper change in potential with its subsequent decrease. The most rapid displacement along the cut results in a sharp change in potential. The onset of smooth slippage is evidence of some redistribution of local mechanical stresses in the neighborhood of the cut and the appearance of a gradient of stresses. This leads to polarization of the region along the cut, manifested in the form of a sharp change in potential. The sharper change in potential prior to displacement is evidence of some local displacement leading to a further redistribution of stresses. This change in electric potential can be regarded as a short-range precursor of impending displacement. The experiment seems to indicate that electric phenomena such as the appearance of static electric fields can be regarded as earthquake precursors. However, in evaluating the anticipated fields it is necessary to clarify the scale effect and the role of moisture in the polarization of rocks or relaxation of charge. Figures 2; references 6: 5 Russian, 1 Western.
[illegible]

UDC [illegible]

ELASTIC DEFORMATION OF PENDULUM KNIFE EDGE AS SOURCE OF SYSTEMATIC ERRORS IN RELATIVE GRAVITY MEASUREMENTS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 267, No 1, Nov 82 (manuscript received [illegible] Jul 82) pp 71-73

[illegible]ANYUK, V. A., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] An analysis of the results of absolute and relative measurements made in the USSR during 1966-1967 revealed a systematic difference of about [illegible] μgal between the points in the international gravimetric network of 1971 situated in Europe and on the other continents, as well as systematic differences between the results of measurements of individual instruments of the TsNIIGAiK (Central Scientific Research Institute of Geodesy, Aerial Mapping and Cartography) pendulum complex attaining 100 or more μgal per 1000 mgal. One of the reasons for the scale factor of the pendulum measurements being different from unity may be failure to make allowance for the elastic deformation of the pendulum knife edge, as a result of which its configuration changes. Along the knife edge the radius of curvature, specific load on the knife and its deformation change considerably. Any attempt at a mathematically precise description of the configuration of the knife edge, much less its deformation, is clearly hopeless. In actuality, it is shown that the scale factor of pendulum measurements is not precisely equal to unity, but to some value 1 - k. For example, a scale factor greater than unity can be caused by the elastic deformation of a more complex configuration than a circular cylinder since even in the extremely simple case of a knife edge in the form of a circular cylinder it is virtually impossible to obtain the numerical value of the scale factor; this is all the more infeasible in the case of a knife edge of more complex configuration. The scale factor may be greater or less than unity and its theoretical determination is scarcely possible. The scale factor can be determined only by pendulum measurements at points on a lengthy standard gravimetric base. References: 5 Russian. [illegible]

UDC [illegible]

[illegible]

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol [illegible], No 1, Nov [illegible] (manuscript received [illegible]) pp [illegible]

[illegible], and [illegible], Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow; Moscow State University imeni [illegible]

[illegible]

However, many physical processes, such as the floating-up of light hot masses of matter during gravitational differentiation, development of convective instabilities of different kinds, can result in impairment of the stationary heat regime of the lithosphere. Any excitation of the lower boundary of the lithosphere by a nonstationary heat flow results in a thinning of the lithosphere and formation of structures of the trap type, as pointed out in an earlier study. The author has already published a series of studies of movement of the lithosphere-asthenosphere boundary in a one-dimensional case for small amplitudes of movement (IZV. AN SSSR: FIZIKA ZEMLI, No 7, p 11, 1978, No 1, p 3, 1979; DAN, Vol 245, No 4, p 821, 1979). Continuing this line, the author here examines the problem of an initially horizontal lithosphere-asthenosphere boundary with its disturbance by a slightly nonuniform heat flow for the specific purpose of constructing a very rough model of trap formation, the point of departure being a system of equations describing evolution of the heat regime of the lithosphere derived in an earlier article. A solution of the problem is found, accompanied by a model example illustrating the initial stage in formation of the trap, and the results of computations of the relative thinning of the lithosphere are given. Figures 1; references 7: 5 Russian, 2 Western.
[illegible]

UDC 550.346

CHANGE IN ROCK RESISTIVITY AS RESULT OF MECHANOELECTRIFICATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 267, No 1, Nov 82
(manuscript received 12 May 82) pp 65-67

BALBACHAN, M. Ya., Institute of Physics of Earth imeni O. Yu. Shmidt,
USSR Academy of Sciences, Moscow

[Abstract] Mechanoelectric phenomena, especially the processes of electrification of rocks during fissure formation and friction, are important to study as earthquake precursors. It was demonstrated earlier that as a result of electrification by friction rocks having dielectric properties, including [illegible] rocks, acquire the properties of electrets. The author investigated the influence of mechanoelectret effects of minerals and rocks on their resistivity. The experiments were made using samples of marble, [illegible], [illegible], basalt and talc measuring 25 x 25 x 10 mm in experiments with friction and [illegible] x [illegible] x 30 mm in an investigation of destroyed samples. All measurements were made with maintenance of a constant moisture content of the samples. Electrification of friction was accomplished by the rotation of one sample relative to another having the same composition, size and degree of polishing of the surface as the first. In virtually all the experiments there were changes in resistivity of the samples with time after the [illegible] of electrification. Over 200 experiments were made. There was a [illegible] of changes in resistivity and surface charge with time. Several variants of the experiments are described. The evidence presented in the article reveals a change in rock resistivity of dielectric rocks as a result of mechanoelectrification. The changes in resistivity are determined by

processes of the development and relaxation of the electret effect. A decrease in resistivity observed during electrification and for some time after its ending is attributable to the freeing of some of the poorly bound charge carriers during the formation and relaxation of residual polarization in the volume of the sample. Manifestations of an increase in resistivity are attributable to the appearance and development of layers impoverished with free charge carriers. A decrease in resistivity in the course of several hours after ending of electrification, subsequent increase in the course of several tens of hours to levels greatly exceeding the initial levels, and subsequent decrease over the course of hundreds of hours have been observed in different rocks both as a result of friction and destruction, including in moisture-saturated samples. This effect can be of importance as a possible cause of baylike changes in the resistivity of rocks accompanying earthquakes. Figures 4; references 4: 3 Russian, 1 Western.
[34-5303]

PHYSICAL MODEL OF FOCI OF DEEP-FOCUS EARTHQUAKES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 82 (manuscript received 29 Mar 82) pp 3-12

KALININ, V. A. and RODKIN, M. V., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] The authors propose a new model of the foci of deep-focus earthquakes based on the rheological properties of matter observed during polymorphous transitions and on seismological data. The earthquakes considered are concentrated near depths of 350 and 600 km. In developing the focal model a study was made of a macroscopic body in an inhomogeneous field of nonhydrostatic σ, T conditions. It is assumed that an equilibrium boundary passes within the body and this boundary separates two polymorphous modifications from one another. Only relatively small shearing stresses are operative along this boundary. When there is an adequately high temperature of the body, when the polymorphous transition is not retarded, a change in the σ, T conditions causes a quasiequilibrium movement of the phase discontinuity. With movement of the boundary the shearing stresses acting on it will be removed by plastic flow along the boundary. The gradual redistribution of stresses occurring in this process cannot cause an earthquake. On the other hand, if the temperature of the body is low a change in σ, T conditions can result in the separation of the equilibrium phase boundary from the boundary really separating the polymorphous modifications from one another. When one of the two modifications is in the region of thermodynamic stability of the other--it becomes metastable. As long as there is no restructuring of the crystal lattice in the metastable phase, the shearing stresses in it persist. With a definite distance of the boundaries from one another in the metastable phase there is a sudden polymorphous transformation. In the short time of the phase transition the region occupied by the metastable phase is attenuated and the shearing stresses acting on it will be removed by a shearing along the phase boundary. This shearing is the source of an earthquake. With a

further change in σ, T conditions the metastable phase is reformed and conditions arise for the occurrence of the next earthquake. The model ties in deep-focus earthquakes and polymorphous transitions in the mantle, explains the shearing nature of movements in the focus and explains the reason for the smallness of the stresses released during an earthquake. As explained in the article, it also reveals the existence of a critical rate of sinking of the lithospheric plate determining the possibility of the occurrence of deep-focus earthquakes in it. Figures 2, tables 1; 60 references: 29 Russian, 31 Western.
[38-5303]

UDC 550.34.016

EARTHQUAKE FOCAL MECHANISM AND STRESSED STATE OF IRANIAN PLATFORM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 82 (manuscript received 12 Nov 81) pp 20-28

ANNAORAZOVA, T. A., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] A study was made of the relationship between the focal mechanism and stressed state of the Iranian platform and tectonic processes transpiring in this region. According to the concepts of the new global tectonics, the boundaries of the Iranian platform coincide with the strike of the principal faults. It has been further assumed that the seismicity and focal parameters of Iranian earthquakes are determined by movement of the Iranian platform relative to the Turan platform (which is assumed to be fixed). The Iranian platform has a complex tectonic structure, earthquake epicenters being situated primarily near its boundaries, but not in a narrow zone--instead in a wide band, suggesting that the boundary between the plates is not determined by individual faults, but by entire systems of faults. The author determined the focal mechanisms of 40 earthquakes on the Iranian platform with magnitudes $M \geqslant 5$ during the period 1973-1978 (the results of these determinations are presented in Table 1 and in Fig. 1). It is shown that compressional and dilatational stresses have maintained for the most part a near-horizontal orientation and accordingly the principal type of focal movement has been displacements along steep discontinuities oriented at different angles to the main faults. In some places there has been a reorientation of the axes of the dilatating and intermediate stresses in the vertical plane perpendicular to the axis of stable horizontal compression. Such a reorientation is possible only under conditions of a stressed state of uniaxial compression caused by a geologically prolonged process of relative movement of the Iranian platform which is manifested in a stability of the direction of the compressional axes in the focal mechanism of earthquakes in a particular region. The mapped patterns of orientation of discontinuities and displacements at the foci of strong ($M \geqslant 5.5$) earthquakes in different parts of the Iranian platform make it possible to assume that the movement of the platform is directed to the NNE (in an azimuth 0°-20°). The forces of horizontal compression in the Lut zone (discussed here in particular detail) are oriented in a NE direction (in an azimuth of about 50°). Figures 3, tables 2; references 8: 3 Russian, 5 Western.
[38-5303]

UDC 550.34.063

TEMPORAL STABILITY IN PREDICTION OF SITES OF STRONG EARTHQUAKES. I. SOUTHEASTERN EUROPE AND ASIA MINOR

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 82 (manuscript received 20 May 81) pp 13-19

GVISHIANI, A. D., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] This article is a logical continuation of a series of studies on the theme "recognition of sites of possible occurrence of strong earthquakes" (in particular, in VYCHISLITEL'NAYA SEYSMOLOGIYA, Nos 6, 7, 8, 9, 10, 11, 13, 1973-1980) in which a solution was obtained for predicting the sites of epicenters of earthquakes with a magnitude $M \geqslant M_0$, this solution being obtained for the problem of classification of a finite set of objects W which usually consists of disjunctive nodes or the intersections of morphostructural lineaments. The discretization and coding of the observable parameters of the objects $w \in W$ makes it possible to represent these objects in the form of binary vectors. This in turn makes it possible to apply classification algorithms with teaching for the binary vectors to the problem. The materials presented here illustrate application of this method in a specific regional study. The author formulates the necessary requirement of temporal stability for prediction of the sites of such strong earthquakes. It is required that the prediction not change with a change in the initial data. A number of mathematical propositions are presented which make it possible to check satisfaction of this requirement. In the example considered it is demonstrated that the classifications of the intersections of lineaments in Southeast Europe and Asia Minor with respect to the possibility of the appearance of epicenters of earthquakes with $M \geqslant 7.0$ in their neighborhood is not dependent on the admissible change in teaching material with time. This is a further argument for regarding the mentioned classifications as a prediction of the sites of occurrence of strong earthquakes. (Also see: A. D. Grishiani, et al., "Validation of Results Prediction of Sites of Strong Earthquakes Obtained by Recognition Methods," IZV. AN SSSR: FIZIKA ZEMLI, No 2, pp 21-36, 1981) References 14: 13 Russian, 1 Western.
[38-5303]

PRECURSORS OF DESTRUCTION OF LARGE ROCK SAMPLE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 8, Aug 82 (manuscript received 15 Dec 81) pp 29-43

SOBOLEV, G. A., SEMERCHAN, A. A., SALOV, B. G., SHPETTSLER, Kh. A., SONDERGEL'D, K. Kh., BADANOV, V. N., KOL'TSOV, A. V., LOS', V. F., NASIMOV, R. M., PONOMAREV, A. V., STAKHOVSKIY, I. R., TERENT'YEV, V. A. and TURETSKIY, I. M., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] The authors made an investigation of the process of destruction of a large rock sample by employing six mechanical, acoustic and electric

methods. This involved use of a large number of sensors for registry of the fields of the corresponding parameters and their variations in time and space. To a certain degree an attempt was made to simulate observations of earthquake precursors in seismically active regions, all on the assumption that an earthquake is a result of destruction of rock masses. It was found that during deformation and destruction the sample behaved as an essentially inhomogeneous medium. The scale of inhomogeneities detected by different methods was considerably greater than the grain size. Dilitancy zones appear as a result of progressive dilatation of soft sectors and are distributed nonuniformly in the sample. It was possible to produce zones of internal local destruction, a situation close to that observed during earthquakes. Zones of local destruction successively appear and disappear in the volume sample. Destruction of the entire sample comes about by accumulation of zones of local destruction. Considerable changes in different physical fields were registered prior to destruction of individual zones in the sample. Macrodestruction of a large sample does not occur suddenly and can be predicted. For the first time in the laboratory it was possible to detect long-lived (hours) anomalies of the electric potential of the sample surface preceding and accompanying internal destruction. During preparation for destruction in the fields of velocities of elastic waves, deformation, resistivity and electric potential there is simultaneous appearance of anomalies of opposite signs so that study of the overall characteristics of the sample does not make it possible to discriminate the precursors of destruction. A "calm" in acoustic emission is observed prior to destruction. A large-scale inhomogenous sample can "remember" the magnitude of the preceding load, manifested in acoustic emission. With approach of macrodestruction of the sample the accuracy in determining the level of the preceding load on the basis of the appearance of acoustic emission decreases. Figures 8, tables 1; references 8: 4 Russian, 4 Western.
[38-5303]

UDC 551.501.721

ACCURACY OF ATMOSPHERIC ACTINOMETRIC RADIOSONDE OBSERVATIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 18, No 9, Sep 82 (manuscript received 30 Jun 81) pp 1000-1003

KOSTYANOY, G. N. and KRASNOVA, T. M., Central Aerological Observatory

[Abstract] The use of actinometric radiosondes became particularly important during the TROPEX-74 program. This made it essential to determine their accuracy characteristics, to determine the errors in ascending and descending fluxes of long-wave radiation in the free atmosphere at nighttime when using the ARZ-1 actinometric radiosonde. The initial studies made along these lines confirmed its accuracy, but a number of subsequent investigations suggested considerably greater errors. In order to clarify this problem the authors carried out experiments in August 1976 at Ryl'sk. The main idea of this series of experiments is as follows. It is assumed that the theory of the ARZ-1 is true within the limits of change in the measured fluxes. Radiometers having the same theory as the ARZ-1 or based on the same assumptions and initial heat balance equations should give values of fluxes identical with the ARZ-1 in the case of paired launchings, despite a difference in the temperatures of the sensing surfaces. Three paired launchings (ARZ1N and ARZ2N) were carried out in 1976. The ARZ1N radiometer is a precise copy of the ARZ-1, but with a change in the processing method. During the time of one cycle of interrogation of temperatures of the ARZ1N and ARZ2N sensing surfaces the probe travels 700-900 m and temperatures are interpolated to a single level. The ARZ2N consists of 2 ARZ 1 radiometers, for one of which the sensing surface is blackened, whereas the second is aluminized. A second series of paired launchings involved a comparison of the ARZ1N and ARZ2P. The ARZ2P radiometer consists of 2 single-plate ARZ1P radiometers, one surface of which is blackened, whereas the second is aluminized. The ARZ1P was assembled of ARZ-1 parts and its theory is based on the same principles as for the ARZ-1. A table gives the statistical characteristics of the differences in ascending and descending fluxes for two of these paired ARZ1N-ARZ2P launchings. The paired ARZ1N-ARZ2N and ARZ1N-ARZ2P launchings confirm the estimates of the errors in determining the fluxes of long-wave radiation in the free atmosphere at nighttime obtained earlier by the authors for the ARZ-1. Figures 1, tables 4; references 17: 16 Russian, 1 Western.
[7-5303]

UDC 551.511.3

COMMENT ON ATMOSPHERIC BAROCLINIC INSTABILITY

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 3 Mar 81, after revision 7 Dec 81) pp 995-997

KORNYAK, V. V., Kuban State University

[Abstract N. A. Phillips examined the phenomenon of baroclinic instability using a two-layer linearized quasigeostrophic model. It was postulated that the main flow, containing a vertical velocity shear, is strictly zonal. In that model for an increase in disturbances it is required that the vertical velocity shear exceeds some critical value. This means that for the development of instability the meridional temperature gradient must exceed the corresponding critical value. Later P. H. Stone (J. ATMOS. SCI., Vol 35, No 4, 1978) demonstrated that the observed mean temperature values never attained a critical value. For explaining this instability Stone proposed a baroclinic adjustment theory: baroclinic disturbances act in such a way as not to allow supercritical gradients. The author here proposes another possible explanation of this instability. It is noted that the Phillips computations were made under conditions of a collinearity of two unrelated vectors: horizontal temperature gradient and Coriolis parameter gradient, which is not the usual situation. Here it is assumed that the main flow, examined in the β-plane, is linear but has an arbitrary direction. This proposition is examined in detail. Two important expressions are derived: with satisfaction of inequality (9) there is a critical ΔU value below which stability is observed; if inequality (8) is satisfied, instability arises with an ΔU value different from zero[ΔU is the vertical velocity shear of the main flow]. It is shown that the most unstable disturbances are pulsations in the zonal direction. The disturbance wave travels in a meridional direction with a certain velocity--this is a transverse wave propagating in a meridional direction. The conclusions drawn in the article are applicable to baroclinic instability in the ocean. References 4: 2 Russian, 2 Western.
[7-5303]

UDC 551.515.3:532.516

EDDY CURRENTS IN FLUID LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 8 Dec 80, after revision 8 Apr 81) pp 980-985

ZAVOLZHENSKIY, M. V.

[Abstract] During the movement of well-developed cloud layers in the atmosphere or water masses in the ocean the lower and upper boundaries of the layer are exposed to different temperature conditions. Situations can arise when the lower boundary is warmer than the upper boundary. The stability of the position of equilibrium of such a layer is possible only in a case when the temperature in the thickness of the layer changes linearly and only with

small values of the temperature gradient. In this article it is demonstrated that a possible form of loss of stability of the equilibrium state of the considered layers of the medium is an eddy current with a vertical axis whose hydrodynamic characteristics attenuate with an increase in distance from this axis. In the formulated problem clouds in the atmosphere (or the water mass in the ocean) are simulated by a layer of infinite horizontal extent consisting of a heavy viscous incompressible fluid conducting heat. The layer rotates with a constant angular velocity ω' about a fixed axis. The ω' value characterizes the Coriolis parameter at the latitude of passage of the eddy. On this basis, using the Boussinesq equations, the author makes a detailed study of the spectral problem of loss of stability of the equilibrium state of such a rotating layer of a viscous fluid characterized by a temperature inversion. It is demonstrated that the loss of stability can occur in the form of eddy currents localized about the axis of rotation. Such currents simulate some properties of waterspouts, tornadoes and other eddies. References 5: 4 Russian, 1 Western.
[7-5303]

UDC 551.463.5:535.36

VISIBILITY OF REMOTE OBJECTS IN SCATTERING MEDIA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 28 May 81) pp 963-969

BELOV, V. V., ZUYEV, V. Ye. and KREKOV, G. M., Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences

[Abstract] Any synthesis of visibility systems must be preceded by a detailed analysis of the influence exerted on the image quality of objects not only by optical system design, but also by external conditions: sources of background and scattered radiation, limited registry conditions, emissive and reflective properties of observed objects and spectral, coherent and polarization characteristics of the short-wave radiation propagating from the object to the receiving system. In seeking to clarify this problem the authors discuss the results of investigation of the transformation of the frequency-contrast structure of the image of remote objects in a scheme for their observation through a scattering medium with increasing distance between the receiving system and the object plane. The described investigations were made with the so-called line-system approach to solution of problems in visibility theory by the Monte Carlo method. It was possible to ascertain the conditions for an extremal influence of the scattering medium on image quality of plane diffusely emitting (reflecting) objects. An interpretation of the derived dependences is proposed and the influence of the background of multiple scattering on line-system characteristics is evaluated. As indicated by the authors, the choice of the optimum value of the H parameter ensuring the best conditions for the visibility of objects is dependent on the purpose of the observation and on energy threshold response and resolution of the image analyzer or recorder. The materials presented in

the article do much to explain the observed dependence of the image quality of objects on the position of the optical receiving system in schemes for high-altitude observation of the earth's surface. Figures 6; references 12: 10 Russian, 2 Western.
[7-5303]

UDC 551.501.71:551.510.534

APPLICATION OF REGULARIZATION METHODS TO SOLVING PROBLEM OF RECONSTRUCTING VERTICAL OZONE DISTRIBUTION FROM UMKEHR EFFECT OBSERVATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 7 Jul 81, after revision 15 Apr 82) pp 944-952

YELANSKIY, N. F. and TEREKHIN, Yu. L., Institute of Atmospheric Physics USSR Academy of Sciences

[Abstract] The determination of the vertical distribution of ozone by the Umkehr method still remains fundamental in investigating the ozonosphere due to its simplicity, relative ease and the possibility of obtaining data for altitudes unattainable for ozonosondes. The article examines the use of different methods for reconstructing the vertical ozone profile on the basis of observation of the Umkehr effect and an attempt is made to determine the most effective approach to this problem. A review of the most commonly employed methods for reconstructing the vertical ozone profile in the world network of ozonometric stations reveals that they are characterized by significant shortcomings associated with imperfection in methods for finding stable solutions. Neither the least squares method nor the maximum probability method can be regarded as a reliable means for solving the Umkehr equation. The Tikhonov regularization method with choice of the regularization parameter on the nonclosure principle is far preferable. The optimum regularization method as applicable to this problem is examined in detail. A measure of the error in the solution is formulated. The effectiveness of the method is illustrated by numerical computations in a closed scheme. In the example cited the vertical ozone profile was reconstructed with an entirely acceptable accuracy. The maximum deviations of the computed profile from a precise profile do not exceed 5%. With a stipulated error in the input data the relative error in the solution does not exceed 11%. The coincidence of the computed and precise profiles indicates that the method of reconstructing the ozone profile on the basis of the Umkehr effect can be highly effective. Figures 1; references 31: 18 Russian, 13 Western.
[7-5303]

UDC 551.521.3:551.510.42

AEROSOL ABSORPTION IN SPECTRAL REGION 0.25-0.8 μm

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 18, No 9, Sep 82 (manuscript received 16 Jul 81, after revision 23 Nov 81) pp 922-932

LYUBOVTSEVA, Yu. S. and YASKOVICH, L. G., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] It is now important to determine aerosol absorption $\alpha(\lambda)$in the visible part of the spectrum in relation to the problem of the increasing global contamination of the earth's atmosphere. The absorption of aerosol samples was measured with an apparatus operating on the basis of a photometric sphere with a diffusely scattering $BaSO_4$ coating. The apparatus is intended for measuring the coefficients of aerosol samples in the range 0.25-0.8 μm, collected on transparent or diffusely scattering backings. For the fractional analysis of the absorption spectra and their subsequent comparison with the integral values of the coefficient of aerosol absorption the samples must be collected with some type of impactor. In this study an analysis was made of the absorption spectra of aerosol samples collected during two summer seasons under pure natural conditions at Abastumani in mountains at an elevation of about 2000 m during 1978 and 1979. During 1978 five-stage impactors were used; in 1979--two-stage impactors. In determining the coefficient of aerosol absorption α on the basis of measurements of light absorption by a sample it is necessary to relate the optical properties of the sample and the properties of individual aerosol particles suspended in the air. It was found that the coefficient of aerosol absorption at Abastumani varies from 0.096 to 0.13 km^{-1}, which is several tens of times less than the coefficient of aerosol absorption in major industrial cities. Fractional analysis of the absorption spectra indicated that the maximum contribution to integral absorption is from particles with a radius $0.16\ \mu m < a < 0.3\ \mu m$. For the finely disperse aerosol fraction absorption in the visible region for the most part is determined by the presence of crystalline carbon in the particles; in the UV region absorption is determined by the presence of organic components. It is proposed that the visible region of the spectrum be used for evaluating the mass concentration of soot on the basis of $\alpha(\lambda)$ measurements. It was found that in the mountains, under pure natural conditions, the mass concentration of soot varies from 0.1 to 2.6 $\mu g/m^3$. Figures 5, tables 2; references 17: 7 Russian, 10 Western.

[7-5303]

UDC 551.52:523.4

EQUILIBRIUM TEMPERATURES OF SELECTIVELY ABSORBING PLANETS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian
Vol 18, No 9, Sep 82 (manuscript received 20 Oct 81) pp 916-921

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[Abstract] If the optical and thermodynamic properties of the atmosphere and the underlying layer of a planet are known, the temperature field is described by models of different complexity, using detailed data on the absortpion and reflection spectra or integral albedo and the atmospheric transmission function. However, it is shown that qualitative evaluations of equilibrium temperatures can be obtained using simple models without detailed allowance for the spectrum. The author here examines the equilibrium temperature of a planetary surface in the presence and absence of an atmosphere. Using a very simple model of the optical properties of the planet (the absorption coefficient is equal to unity in the selected part of the spectrum and zero outside it) it is easy to describe the dependence of equilibrium temperature on the critical wavelength, atmospheric greenhouse and antigreenhouse effect. Using this approach it was possible to compile Table 1: Equilibrium Temperatures of the Gray Disk and Sphere of the Planets With Allowance for Albedo and the Critical Wavelength. Three different models of the planetary absorption spectrum are considered, for example, a planet whose surface is an ideally black body and whose atmosphere is a selectively absorbing homogeneous isothermic layer with an absorption coefficient equal to unity in part of the spectrum, whereas the remaining part is ideally transparent. Specific computations are presented showing that a stepped model of the atmospheric absorption spectrum gives correct estimates of the surface temperatures of the Earth and Mars. The optical properties of the earth's atmosphere and surface in the solar and thermal parts of the spectrum to a considerable degree compensate one another. On Mars the planetary albedo virtually compensates the atmospheric greenhouse effect. Figures 3, tables 2; references: 10 Russian. [7-5303]

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COMPATIBILITY OF COMPUTED AND MEASURED THERMAL RADIATION FLUXES

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[Abstract] A study was made of the influence of errors in measurements and computations of the fluxes of thermal radiation and errors in the measurement of initial data on the degree of comparability of computations and measurements. The analysis was based on 84 cases of actinometric radiosonde observations made in cloudless weather over the tropical Atlantic on Soviet ships in the GATE (TROPEX-74) experiment. All conceivable sources of such

inconsistencies are examined in detail: errors in measuring fluxes, errors in computing fluxes, errors in measuring initial data used in computing the fluxes (temperature, humidity, emissivity of underlying surface) and incompleteness of the optical model of the atmosphere. It is clear that the sum of all these errors, together with additional allowance for absorption by ozone, aerosol, minor gases and complexes of water vapor molecules, does not ensure a proper agreement of the computed and measured fluxes of descending radiation in the stratosphere and upper troposphere. The following are postulated, therefore, as the reasons for the observed difference between computations and measurements: 1) an enormous quantity of aerosol is concentrated in the upper layers of the atmosphere, not in agreement with measurements of optical thickness determined from the sun; 2) with the low pressures in the high layers of the atmosphere it is necessary to take into account the change in the form of the lines and proceed from integral computations of the fluxes of descending radiation to spectral computations for individual lines; c) the error in actinometric radiosonde measurements of the high layers of the atmosphere must be greater than surmised. Figures 2, tables 12: references 24: 16 Russian, 8 Western.
[7-5303]

UDC 550.388.2

SCHUMANN RESONANCES IN HIGH LATITUDES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 267, No 4, Dec 82 (manuscript received 7 May 82) pp 815-818

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[Abstract] In the extremely low frequency range of the earth's electromagnetic field (several-hundreds cps) there are so-called Schumann resonances (characteristic frequencies of the earth-ionosphere resonator) whose existence is caused by the presence of a waveguide between the earth and the ionosphere. The principal source of excitation is assumed to be vertical lightning discharges, but there has been no direct experimental evidence of this excitation mechanism for this frequency range; the picture is complicated, however, by some authors who attribute this phenomenon to cosmic sources. In order to clarify this problem the authors used measurements made on the "SP" drifting station in the spring and summer of 1979-1980. A cycle of discrete (Δt = 3 hours) measurements of the $H_{x,y}$ and $E_{x,y}$ components was made in the window of the first Schumann resonance (6-10 cps) and representative statistics were obtained for the background characteristics of extremely low frequency of the electromagnetic field in the frequency range 0.5-100 cps. It was found that the first resonance frequency is split into three sublevels. This characteristic is consistent with a model of a dipole source of the geomagnetic field and excitation of the resonator by global thunderstorm activity of the earth's equatorial zone. In the analyzed measurements 60-70% of the observed spectra

are indicative of excitation by lightning, splitting is absent in 30-40% of the cases, and only a few cases correspond to a possibility of excitation by cosmic sources. However, it appears that in some cases both sources of resonator excitation introduce approximately equal contributions to the total extremely low-frequency electromagnetic field. An additional factor confirming the presence of a source of excitation of magnetospheric origin could be an absence of a drift of the lateral branches of the triplet together with clearly defined shifts of the central branch. In any case the existence of a magnetospheric source of excitation of the earth-ionosphere waveguide is confirmed. Figures 3; references 7: 4 Russian, 3 Western.
[48-5303]

UDC 551.521.3

CONSTRUCTING REGIONAL SEMIEMPIRICAL MODELS OF ATMOSPHERIC OPTICAL CHARACTERISTICS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 265, No 6, Aug 82 (manuscript received 6 May 82) pp 1353-1356

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[Abstract] Various models already exist which make it possible to describe the spectral variation of atmospheric optical thickness in the transparency windows, but a common shortcoming of these models is that they have a static character, only reflect average conditions and do not take into account real fluctuations of atmospheric optical density associated with the variability of synoptic processes. This article gives a new approach to formulation of such a model of change in optical thickness in the transparency windows. The proposed model of optical state of the surface air is based on synthesis of the results of generalization of in situ optical experiments conducted under various weather conditions and largely free of the mentioned shortcomings. In constructing the aerosol block of this model the authors rely on an optimum set of criteria for identifying the optical state of aerosol. The input parameters of the aerosol block are: meteorological range of visibility, relative humidity and air temperature; the parameters include a synoptic criterion: the position of the East European polar front relative to the region where the experiments are carried out (this characterizes the geographical origin of the air mass). The described model embraces different states of optical weather, each of which is characterized by a set of input parameters, and most importantly, by a definite profile of the spectral dependence of the volume coefficients of aerosol attenuation α_λ. In general form the optical thickness in the windows of atmospheric transparency due to aerosol attenuation and continuum absorption of radiation by water vapor is described by the expression

$$\sigma_\lambda = \left\{ \alpha_{0.55} [n_0 + n_1 \lambda^{-n_2} + \beta_\lambda] + (K_{1\lambda} P + K_{2\lambda} e) \frac{21{,}67\, e}{273 + t\,(^\circ\mathrm{C})} \right\} L.$$

This expression can be used in computations of radiation losses during propagation of radiation in the earth's atmosphere. The total error in the diagnosis of optical thickness by the proposed model is about 15-20%. Tables 2; references 11: 9 Russian, 2 Western.
[63-5303]

UDC 551.521.3+535.361

INVARIANCE OF OBSERVATION SYSTEMS IN THEORY OF VISIBILITY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 6, Oct 82 (manuscript received 26 Apr 82) pp 1353-1356

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[Abstract] The application of methods for analysis of linear systems in the theory of visibility is one of the promising directions in development of this theory. This makes it possible to analyze the influence of a scattering medium on image quality in schemes for both passive and active observation of objects of any size and shape. The necessary allowance for the processes of absorption and scattering of radiation in the medium separating the object and receiving system is possible by one of the known methods in transfer theory. The most general results in the theory of visibility have been obtained by solving the transfer equation in a small-angle approximation. This article outlines a linear-systemic approach to problems in the theory of visibility for turbid media. The assumption has usually been made that the observation systems are invariant. The results of investigation of the influence of position of the scattering layer on the observation path on image quality are reviewed on the assumption of such invariance. However, there are contradictions in these results and an effort is made here to resolve these inconsistencies. An evaluation is made of the influence of noninvariance of the observation systems on the dependence of the linear-systemic characteristics on the t parameter. Several numerical experiments were made by the Monte Carlo method. The computations were made for aperture-geometrical and optical parameters of a scheme for observing diffusely radiating objects through a layer of a turbid medium. The results were obtained on the assumption that the observation system has circular symmetry. In the first stage of the experiments invariance was assumed; in the second stage noninvariance was assumed. The principal conclusion drawn on the basis of these experiments was that the image quality of objects is determined not only by the position of the scattering layer on the observation path, but also by the spatial spectrum of the object itself. For example, there is an improvement in the image quality of small objects with approach of the scattering layer to the detector. The results show that in some problems in the theory of visibility it is essential to take into account the noninvariance of observation systems to shifting of a point source in the object plane. Figures 2; references: 10 Russian.
[33-5303]

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